

GEMMOLOGY
QUESTIONS AND ANSWERS

a study book for
GEMMOLOGY STUDENTS

by

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FOREWORD

Six years after the death of my father, George Stevens, and 34 years after the publication of the original paper edition, I decided to assemble this facsimile electronic version of the book to preserve my father's hard work for future gemmologists, historians and family.

George typed the book up on my early Apple II computer and printed out the pages for copying and assembly at a local print shop. He sold copies to his colleagues in the NSW Branch of the GAA as a study aid based on notes that he had prepared while studying for a Dip. Gemmol.

The 5¼" floppy discs then languished in a box for decades. Following George's death at the age of nearly 83 in late 2011, I sorted through several boxes of papers, books and photos and discovered the discs. They piqued my interest. So after much searching on the Internet, I acquired a small purpose-built interface card (the FC5025 from Device Side Data in the USA) and an old floppy disc drive, plugged them together into a USB port of my Apple Macintosh and ran the supplied software. It was both amazing and rewarding to find that the files had all been preserved.

Then running Virtual II software, which emulates an Apple II computer on the Mac, I was able to copy the files off the retrieved disc images and opened them in a text reader. I then assembled them in MS Word and created this facsimile edition.

This electronic copy is not an exact image-for-image reproduction of the original, but I've corrected several errors that escaped George's notice.

Matthew Stevens
Thornleigh NSW Australia
February 2018

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DEDICATION

This book is dedicated to my wife Shirley, who for the past two and a half years has willingly co-operated to allow me uninterrupted time, firstly to study this fascinating subject of Gemmology, and secondly to put my hard won knowledge in a form which may be useful to many other, future students.

ACKNOWLEDGEMENTS

It goes without saying, but I will say it, that I wholeheartedly acknowledge all of the people, both past and present, who in their various ways have provided information which I have gathered together in this unique book. Among these are previous authors, my lecturers and laboratory demonstrators, my friends in the very pleasant study groups we used to attend on Saturday afternoons, and members of the profession with whom I have come in contact. Of particular assistance to me in polishing the final product are those close associates who willingly gave some of their precious time to critique the first draft. I and my readers are indebted to these eight stalwarts. But the person to whom I owe the most is my son Matthew without whose long-suffering patience, genius and Apple™ home computer (with Zardax™ word processor) the text of this book would still be at page 1 on the family typewriter.

GEMMOLOGY QUESTIONS AND ANSWERS

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GEMMOLOGY STUDENTS' QUESTIONS AND ANSWERS

PREFACE

This book is intended primarily as an aid to study for Gemmological students.

The five hundred questions and answers had their origin in my own struggles over two years endeavouring to meet the high standard of knowledge demanded by the Board of Studies of the Gemmological Association of Australia. Although the work will be of value to all students, it will be of particular use to those students who, like myself at the time, are undertaking the course of study for vocational reasons.

As a student I frequently felt the need to test my progress in terms of accuracy and extent of knowledge acquired. To meet this need I developed, quite laboriously, a card system of questions and answers. Now, having done the hard work, I thought it should be turned to good use by reproducing the questions and answers in a readily accessible and usable form for the benefit of others. Hence this book.

Periodically a question may appear to be duplicated, but it will be phrased in a different way. This is deliberate and will cause the student to consider the matter from a different perspective. A simple analogy to illustrate the need for this is that when examining a gemstone one should always look at it from different perspectives. In so doing, one invariably sees and understands more.

Inevitably it may be considered by some readers that there will be omissions from the book. Perhaps, but hopefully not, there may be the odd error. Whatever the cause for reader comment I would encourage and indeed welcome constructive criticism.

George Stevens
Greenwich NSW
March 1984.

GEMMOLOGY STUDENTS' QUESTIONS AND ANSWERS

INTRODUCTION

The questions and answers have been grouped into two broad categories of Physical Gemmology and Applied Gemmology. The former deals with structure of matter, basic crystallography, physical and optical properties, and instruments. Applied Gemmology deals with gem types - their occurrence and characteristics, synthetics, and treatment. Questions within each group have been organised in random sequence. However, for the student who wishes to test himself/herself thoroughly on a particular topic, the index has subjects listed in alphabetic sequence together with the question number relating to that topic.

To use this book, simply provide yourself with a pen, two pieces of paper, and open the book wherever you prefer. One piece of paper is to jot down notes for further study as you progress through the questions. The other piece of paper should be used to cover the open page entirely. Move this latter piece of paper slowly down the page and the text of the question will be revealed as you uncover it. When you see the short horizontal line appear at the end of the question, stop and read the question. Carefully! Don't skip through it. Think about it. Gather your facts. Organise them. Frame your answer, either in your mind or write it down as well. Satisfied that you have understood the question and answered it to the best of your ability? Are you sure? OK, now for the moment of truth. Slide your piece of paper down further and stop at the next line. Read the answer. Were you correct? Yes? Well done. No? Then back to the drawing board to read up some more and with a strong resolve to do better next time. Now on to the next question.

In your use of the book try the following variations, and develop others to suit your own particular learning style.

1. Use the index to help you to concentrate on a particular topic.
2. Go from page 1 progressively through the book.
3. Do every alternate page.
4. Start at the end and work towards the front.
5. Develop a random number sequence.

The reason for suggesting this practice is that if you consistently go through the same routine you will inevitably start to remember the sequence and maybe even get to the stage of knowing which question is coming up next. This is not learning to handle the real life situations where problems for our resolution rarely present themselves in a conveniently recognisable pattern. You have to learn to expect the unexpected.

PART ONE - PHYSICAL GEMMOLOGY

Q1. What is an atom?

A1. An atom is the smallest particle of an element which can exist and maintain its identity. Also defined as the smallest particle of an element able to take part in a chemical reaction with other elements. It is generally electrically neutral.

Q2. What is cleavage? Give some examples.

A2. Cleavage is the tendency for a substance to break or split in certain defined directions which are parallel to the crystal faces or possible crystal faces. Diamond has octahedral cleavage. Topaz has basal pinacoidal cleavage. Quartz, Tourmaline, Beryl, Corundum have no cleavage.

Q3. What, in correct sequence are the colours of the visible light spectrum?

A3. Red, orange, yellow, green, blue, indigo, violet.

Q4. What is meant by the term crystal habit?

A4. Habit is the general shape that a crystal will preferentially take, e.g. diamond, octahedral.

Q5. Why is a stone cut with a girdle? How thick should the girdle be?

A5. The girdle exists primarily to assist in the setting of the stone. A thick girdle wastes material and does nothing to enhance the stone's appearance. A girdle that is too thin leads to breakage. A girdle of 1% to 3% of the diameter of the stone is considered a suitable optimum.

Q6. What is Snell's Law?

A6. Snell's Law states that the refractive index of a medium is the sine of the incident angle divided by the sine of the refracted angle when:
1. Light is passing from air to the medium and
2. That light is monochromatic sodium yellow light of 589 nm.

PART ONE - PHYSICAL GEMMOLOGY

Q7. What is a gemstone?

A7. A gemstone is a natural or synthetic substance of mineral origin having beauty, rarity, and durability. Other substances of animal and vegetable origin tend to be referred to as organics. Pearl might be considered to be an exception to this latter statement.

Q8. What is dispersion?

A8. Dispersion is the splitting of white light into its component spectral colours.

Q9. What is fracture?

A9. Fracture is breakage in any direction not related to cleavage or parting. It is non-directional.

Q10. What are the three major classifications of rock? Give an example of each.

A10. Igneous - basalt, granite, dolerite.
Sedimentary - limestone, sandstone, shale.
Metamorphic - quartzite, marble, gneiss.

Q11. Which of the following four options shows the correct hardness relationship?

- a) Calcite, Apatite, Topaz, Quartz.
 - b) Orthoclase Feldspar, Apatite, Fluorite, Quartz.
 - c) Calcite, Fluorite, Orthoclase Feldspar, Apatite.
 - d) Corundum, Topaz, Quartz, Talc.
-

A11. d) is the correct answer, as all are in descending order of hardness.

Q12. What is a three phase inclusion?

A12. It is a gemstone inclusion comprising an enclosed cavity containing a liquid, a solid, and a gas.

PART ONE - PHYSICAL GEMMOLOGY

Q13. What is light interference?

A13. When two light rays are travelling along the same path and are out of phase with each other, they will interfere with each other such that there will be periodic cancellation or reinforcement of one or more colours. this is the cause of the play of colour in thin films.

Q14. What is luminescence?

A14. Luminescence is the effect of visible light emanating from a substance when the substance is stimulated by an external influence. Triboluminescence occurs when a substance is rubbed or scratched. Fluorescence is caused by the stimulus of electromagnetic radiation. Thermoluminescence is caused by heating. Phosphorescence is self generated and occurs in a decaying cycle after the stimulating energy source is removed.

Q15. What is lustre?

A15. Lustre describes the quality of reflected light from a stone, and is determined by the proportion of incident light reflected from the surface. This in turn is a function of the RI and hardness of the stone.

Q16. What is parting?

A16. This is breakage along a twin plane. It is also known as false cleavage. When lamellar twins split, this is known as parting.

Q17. What is refraction of light waves?

A17. It is the bending of light waves when they pass from one medium to another of different density, e.g. from air to glass, the direction and the velocity of the light waves are changed.

Q18. When light is travelling from a less dense to a more dense medium, are the waves bent towards or away from the normal?

A18. Towards the normal.

PART ONE - PHYSICAL GEMMOLOGY

Q19. What is density?

A19. Density is mass per unit volume of a substance. Usually expressed in kg per cubic metre or grams per cubic centimetre.

Q20. What is twinning?

A20. Twinning is the effect in a crystalline structure where one or more parts of the crystal lattice are rotated 180 degrees with respect to each other. Twinning is characterised by re-entrant angles.

Q21. What is valency?

A21. This is the term given to the combining power of an element. It is a measure of the number of atoms of hydrogen with which it can combine or which it can replace. It depends upon the number of electrons in the outer shell of the atom and is never greater than 7.

Q22. What are the three criteria for describing cleavage?

A22. Firstly the texture of the face which develops e.g., perfect which is flat and smooth, imperfect which is rough and irregular. Secondly the ease with which cleavage is obtained, e.g. Mica with a finger nail, Diamond with a knife edge and a sharp blow. Thirdly the name of the face which develops e.g., octahedral, pinacoidal.

Q23. What is the range of the visible spectrum? Express your answer in nanometres.

A23. The red end is approximately 700 nm, and the violet end is approximately 390 nm.

Q24. When a light wave is reflected, the angle of incidence equals the angle of reflection. Where is the angle of incidence measured?

A24. The angle of incidence is measured between the incident ray and the normal. The normal is perpendicular to the tangent of the reflecting surface.

PART ONE - PHYSICAL GEMMOLOGY

Q25. What is the wavelength of X-rays used in gemmological investigations?

A25. 10 to 0.1 nanometres.

Q26. What are the names given to the major crystal habit types? Describe each with a few words.

A26. Acicular - Needle like
Bladed - Like a knife blade.
Blocky - Blocked shapes.
Columnar - Like a column
Equant - Equal in all directions e.g., cubic system
Tabular - Shaped like a book.

Q27. In order of occurrence, what are the major processes in cutting a diamond?

A27. 1. Sawing. 2. Cleaving. 3. Bruting or Rhondisting. 4. Cross cutting. 5. Brilliant cutting.

Q28. What is a mineral?

A28. A mineral is a homogeneous substance produced by the inorganic processes of nature, having physical and chemical properties which are constant within narrow limits. The structure is usually but not always crystalline.

Q29. Can dispersion occur where there are non-parallel surfaces in a crystal?

A29. Dispersion can only occur where there are non-parallel surfaces e.g., a prism.

Q30. Igneous rocks have three sub-classifications. What are these? Give an example of each.

A30. Acid - Rhyolite, Quartz, Porphyry, Granite.
Intermediate - Andesite, Microsyenite, Diorite.
Basic - Basalt, Dolerite, Gabbro.

PART ONE - PHYSICAL GEMMOLOGY

Q31. What are transition elements?

A31. These are elements in which the electrons in the outer orbital shell may move to the adjacent shell. In practice they are the d block elements of the periodic table, all metals, such as iron, nickel, copper, silver, gold.

Q32. Give some examples of good cleavage.

A32. Topaz, basal or pinacoidal, one direction only, easy.
Spodumene, prismatic, therefore in two directions, moderately easy.
Calcite, rhombohedral, therefore three directions, moderately easy, perfect.
Diamond, octahedral, therefore four directions, difficult, perfect.

Q33. There is another term synonymous with RI. What is this?

A33. Optical density.

Q34. Why is it that when white light falls on an object the human observer sees a colour which may not be white e.g., a red Ruby?

A34. White light is a composite of the colours of the spectrum. Some of these colours are absorbed in varying degrees by the object. The colours which are the least absorbed and are reflected are those seen by the observer.

Q35. What are the causes of variation in crystal growth?

A35. Reduction in growth solution, change in space available, change in temperature, change in composition of the fluid, change in direction in which the fluid is travelling.

Q36. What are the main considerations when cutting a transparent colourless stone?

A36. For best effect it needs maximum return of light e.g., brilliance or life, maximum dispersion or fire and maximum weight return.

PART ONE - PHYSICAL GEMMOLOGY

Q37. What does halohedral mean?

A37. It means a crystal with full symmetry or shape.

Q38. Which, of the red and violet rays, is bent more than the other when dispersion occurs?

A38. The violet ray is bent more than the red ray because shorter wavelength.

Q39. Sedimentary rocks have three sub-classifications. What are these and identify the cause or origin?

A39. The three sub-classifications are Clastic, Organic and Chemical. Clastic rocks have developed as a result of mechanics in nature. They are caused by the action of wind, rain, temperature variations, acid waters and vegetable growth. Organic deposits have developed from living matter e.g. Coral, Jet, Amber. The classification known as chemical have developed as a result of precipitate action, where a volume of water in one state, e.g. hot, can hold a chemical such as a salt in suspension but which in another state, e.g. cold, facilitates crystallisation. Some examples are silica becoming chert or opal, iron becoming ironstone.

Q40. True or false: The harder the mineral, the better will be the polish it will take, the higher will be the lustre, and the sharper will be the facet edges.

A40. True.

Q41. Name some gemstones which typically have three phase inclusions.

A41. Colombian Emeralds, Australian and Sri Lankan Sapphires, Topaz, Fluorite.

Q42. What is orient?

A42. This is a particular case of light interference. The iridescent lustre of a pearl is due to the overlapping plates of aragonite, and is called orient.

PART ONE - PHYSICAL GEMMOLOGY

Q43. What is fluorescence? What is phosphorescence?

A43. When a substance is irradiated by electromagnetic energy such as from UV light or X-rays, it may glow a particular colour of a wavelength longer than that of the stimulating energy source. This is fluorescence. If a coloured glow persists after the stimulating energy is removed, this is phosphorescence.

Q44. What are the factors which influence most the lustre of a gemstone?

A44. Firstly the degree of polish which in turn is a function of the hardness of the stone. Secondly the RI which has an influence on the quality and quantity of the reflected light.

Q45. Which gem mineral has well developed parting parallel to the basal plane?

A45. Lamellar twinned Corundum.

Q46. Which is the correct answer to the following statement?
"Wave reversal accompanies..."

a) asterism. b) reflection. c) refraction. d) change of velocity.

A46. b) reflection.

Q47. What is specific gravity, SG?

A47. The SG of a substance is the ratio of its weight to the weight of an equal volume of pure water at a temperature of four degrees Celsius.

Q48. What is an observable characteristic of twinning?

A48. Re-entrant angles or notches.

PART ONE - PHYSICAL GEMMOLOGY

Q49. What is the atomic weight of an element?

A49. The weight of a fixed number of atoms of the element relative to that of an arbitrary standard, carbon 12.

Q50. When light travels from a less dense to a more dense medium the rays are bent. Does the degree of bending depend upon the wavelength of the light ray?

A50. Yes. This is the principle of operation of a prism creating a light spectrum from composite white light. The longer the wavelength e.g., red, the less bending occurs.

Q51. Comment on the differences in appearance of crystal faces and cleavage planes. Compare with a polished face.

A51. Cleavage planes have a stepped irregular surface, the lustre is usually greater than that of crystal faces and they usually show no signs of etching. Crystal faces may show horizontal or vertical striations which always run the entire length of the face. A polished stone will have no striations but may show polish marks.

Q52. What does the word idiochromatic mean? Give an example.

A52. Simply expressed it means self-colouring. Idiochromatic minerals are those in which the colouring is due to some essential constituent. (See allochromatic, Q84.) Examples are Peridot - iron coloured, Malachite - copper coloured.

Q53. What are the effects of variation in crystal growth?

A53. Unequal face development, growth hillocks, hoppers (depressions), parallel overgrowths (phantom or sceptre crystals), spiral growths, oscillating striations (seen in Quartz), etching (dissolving of the crystal).

Q54. What are the main considerations when cutting a transparent coloured stone?

A54. The main considerations are brilliance and colour/pleochroism obtained by correct cutting.

PART ONE - PHYSICAL GEMMOLOGY

Q55. What does hemihedral mean?

A55. Hemihedral means half symmetry or shape.

Q56. What is another name for dispersion?

A56. Fire.

Q57. What are metamorphic rocks?

A57. These are rocks which are formed and altered by the effects of heat and pressure within the earth.

Q58. What is tenacity? Give an example.

A58. Tenacity is the ability of a substance to hold together when subjected to mechanical stress. It is also indicative of resistance to crushing. A tenacious or tough mineral is Jade. By comparison, at the other end of the scale, Emerald is brittle, but harder.

Q59. What are healed fractures? What are some descriptive names given them?

A59. The cracks and/or cleavages which have split open while the crystal has been growing, and which have been filled with the feed solution surrounding the crystal. As the crystal continues to grow the fractures have healed over and the intruded solution has been sealed inside. They are variously called feathers, fingerprints, gossamer, fluid films.

Q60. What is a Chelsea filter?

A60. It is a dichromatic filter which transmits in two regions only of the visible spectrum, viz., deep red at 690 nm, and yellow/green at 540 nm.

PART ONE - PHYSICAL GEMMOLOGY

Q61. What is opalescence?

A61. This is a particular case of light interference. It is a reflection of a milky or pearly light from within the mineral. Moonstone displays this effect. Opalescence should not be confused with play of colour in precious Opal. Note that opalescence stays no matter what the orientation of the stone. (See sheen, Q94.)

Q62. What colour(s) will synthetic Ruby show under long-wave and under short-wave UV?

A62. Verneuil, Chatham and Kashan Ruby all show a very strong red under LW UV, and a strong red under SW UV.

Q63. What are the main categories of lustre? Give an example of each.

A63. Adamantine - Diamond, Zircon.
Metallic - Gold.
Pearly - Pearl.
Resinous - Amber.
Vitreous - Quartz and most gemstones.
Waxy - Turquoise.

Q64. Express RI in terms of light.

A64. RI equals the velocity of light in air divided by the velocity of light in the medium.

Q65. What is the formula for determining SG by the direct weighing method?

A65. SG equals $X \times T$ divided by $(X - Y)$, where X is the weight of the substance in air, T is the density of the liquid used (pure water is 1) and Y is the weight of the substance when immersed in the liquid.

Q66. What are the major classifications of twinning?

A66. 1. Contact or rotational.
2. Repeated - a) cyclic; b) polysynthetic.
3. Interpenetrant or penetration.

PART ONE - PHYSICAL GEMMOLOGY

Q67. What is the critical angle of a medium?

A67. When light is travelling from a more dense to a less dense medium the critical angle is that where light ceases to be refracted out of the medium and is refracted along the medium interface.

Q68. What is an ion?

A68. An atom with one or more additional, or one or more fewer outer-shell electrons than those existing in the balanced state.

Q69. What colours are produced by the transition element chromium? Name some stones so affected.

A69. Chromium produces both red and green. Some of the stones so affected are Ruby, Emerald, red Spinel, Jadeite, Demantoid Garnet, Alexandrite.

Q70. In crystallography, what is a form? Give two examples and identify the crystal system where they are formed.

A70. A form is an assembly of crystal faces, all of which intersect the crystal axes in the same way. Some forms are prisms, found in all but the isometric and triclinic systems. Domes are found in the orthorhombic and monoclinic systems. Cubes, octahedrons and trapezohedrons exist in the isometric system. Pyramids are found in the tetragonal, hexagonal, trigonal and orthorhombic systems.

Q71. How are translucent stones best oriented for cutting?

A71. These are cut for colour and for some optical effect or both. The usual shape is cabochon.

Q72. What coloured stones show dispersion to the best advantage?

A72. Coloured stones rarely show dispersion because colour masks the effect of dispersion. Colourless stones such as Spinel, Diamond and Zircon show dispersion.

PART ONE - PHYSICAL GEMMOLOGY

Q73. What are the causes of the heat which in turn influences the formation of metamorphic rocks?

A73. Intrusion of magma - at about 800 degrees Celsius. Increase with depth - about 17 degrees Celsius for every kilometre of increased depth. Friction due to movement. Hot gases and liquids heating the surrounding rock.

Q74. If a plate test is used to test hardness, should the examiner start with a hard plate and work towards the softer plates or vice versa? Why?

A74. If plate testing is used it should commence with the softer plates to minimise the risk of damage to the stone.

Q75. Name some gemstones which typically have healed fracture inclusions.

A75. Beryl, Kornerupine, Quartz, Ruby, Sapphire, Spessartite Garnet, Spinel, Topaz.

Q76. What colour do synthetic Emeralds show when viewed through a Chelsea filter?

A76. A strong red.

Q77. What is the name given to the optical phenomenon which allows the human eye to detect a join on the girdle of a doublet?

A77. Lustre. The eye discriminates between the two different lustres of the cemented materials.

Q78. In doubly-refractive biaxial stones, how many polarised rays are there? Are these constant?

A78. There are three rays. All vary with direction.

PART ONE - PHYSICAL GEMMOLOGY

Q79. Approximately what is the SG of Amber, Quartz, Diamond?

A79. Respectively 1.08, 2.65, 3.52.

Q80. What is a simple twin?

A80. A simple twin is where a part of a crystal appears to be rotated by 180 degrees about an axis, called the twin axis, which is perpendicular to the twin plane.

Q81. When light is travelling from a more dense to a less dense medium, what is the behaviour of the light rays:
a) at angles less than the critical angle
b) at angles greater than the critical angle.

A81. a) light waves obey the laws of refraction
b) light waves obey the laws of reflection.

Q82. What is a molecule?

A82. A molecule is the smallest particle of a compound which can exist and maintain its identity as that compound, rather than its constituent atoms. It is composed of two or more distinct atoms in a chemically stable configuration.

Q83. Some gems show pronounced cleavage. Some of these will cleave in one direction only while others will cleave in more than one direction. List one stone each as an example of pronounced cleavage in 1, 2, 3 & 4 directions. If you can, state to what the cleavage in each case is parallel.

A83. One direction Topaz basal pinacoid. Euclase clinopinacoid. Epidote basal pinacoid.
Two directions Orthoclase basal and clinopinacoid. Spodumene prism.
Three directions Dioptase rhombohedron. Synthetic Spinel cube. Calcite rhombohedron.
Four directions Diamond octahedron. Fluorite octahedron.

PART ONE - PHYSICAL GEMMOLOGY

Q84. What does the word allochromatic mean?

A84. Allochromatic means that the colouring in the stone is due to impurities. By removing the impurities the colour will change but the stone remains the same (see idiochromatic, Q52). Examples of allochromatic colouring are iron and titanium coloured Sapphire, and chromium coloured Emerald.

Q85. Aggregate types of crystalline structures have descriptive names such as fibrous, meaning those minerals which form in long slender crystals, e.g. asbestos. Name at least five other aggregate types and use a few words to describe each.

A85. 1. Massive or granular or compact - many interlocked crystals or grains without crystal faces, uniform or varying in size.
2. Globular - like bunches of grapes e.g. Malachite.
3. Foliated or lamellar - thin platy structures e.g. mica.
4. Bladed - an aggregate of blade-shaped crystals.
5. Divergent - An aggregate of diverging crystals.
6. Dendritic - moss-like.
7. Reticulated - criss-cross network.

Q86. Why are many Sapphires cut in an oval shape?

A86. This is a compromise of best colour and maximum weight. Best colour is down the C axis, but for maximum weight it is best to cut the table parallel to the C axis.

Q87. What is the meaning of the word hemimorphic?

A87. When a doubly terminated crystal has different forms at each end it is said to be hemimorphic e.g. Tourmaline.

Q88. What type of light source shows dispersion to the best advantage?

A88. Point source light.

PART ONE - PHYSICAL GEMMOLOGY

Q89. What does the term metamict mean?

A89. Metamict is the name given to the condition, where a crystalline substance has been broken down into an amorphous structure by the process of internal radiation, caused by the presence of radioactive material. This is particularly evident in Zircon.

Q90. What are the causes of pressure which in turn influence the formation of metamorphic rocks?

A90. Crustal movements and depth. Regarding this latter, the estimated weight is 2.5 thousand tonnes per square metre per kilometre of depth.

Q91. A hardness of 7 on the Mohs scale is considered as important. Why?

A91. Most of the abrasive particles in the air and which affect jewellery being worn have a hardness of up to 7. Thus stones set into jewellery which is to be constantly subjected to everyday abrasive dust should have a hardness of greater than 7.

Q92. What is a negative crystal?

A92. These are angular cavities, the outline of which coincide with a possible crystal form of a mineral in which they occur.

Q93. Which Emeralds appear green when viewed through a Chelsea Filter?

A93. Those from South Africa and India. Also Soude Emeralds.

Q94. What is sheen?

A94. Sheen is a particular case of light interference; the scattering of light due to thin lamellae such as in Moonstone. Note that sheen tends to move as the stone is moved. (See opalescence, Q61.)

PART ONE - PHYSICAL GEMMOLOGY

Q95. What are the names given to the light rays in biaxial stones?

A95. Alpha is the ray with the lower numerical value of RI. Gamma is the ray with the higher value. Beta is the one in between.

Q96. When using a hydrostatic balance, what is the minimum weight which can be determined with accuracy?

A96. 200 milligrams is the lowest practical limit.

Q97. What is covalent bonding?

A97. This is the sharing of electrons between atoms. In a covalent bond the shared electrons remain attached to the parent atom. The individual attractive forces for the electrons are approximately equal.

Q98. Will all anisotropic stones show distinct pleochroism?

A98. No. Pleochroism is difficult to detect in some stones, e.g. Zircon.

Q99. With reference to crystal terminology, what does euhedral mean?

A99. Euhedral means good faces shown.

Q100. How is dispersion measured? Give detail and an example.

A100. Dispersion is measured by the RI difference for two specific wavelengths at opposite ends of the spectrum. The Fraunhofer solar spectrum is the standard used, there being two strong lines at 687 nm, the B line in the red, and at 438 nm, the G line in the violet. The method is to calculate the RI for each of these two wavelengths and note the difference. For example in Diamond, G at 438 nm has an RI of 2.451, while B at 687 nm has an RI of 2.407. The difference between these two RI measurements is 0.044, the dispersion for Diamond.

PART ONE - PHYSICAL GEMMOLOGY

Q101. Substances have varying degrees of transparency to X-rays. This characteristic is directly related to a measurable constant. What is this constant? What is the value of this to the gemmologist?

A101. The lower the atomic weight, the more transparent to X-rays is the substance. This phenomenon is of value to the gemmologist as a diagnostic aid. One example is in assisting to differentiate between type 1 and type 2 Diamonds. Another is in differentiating between natural and cultured Pearls.

Q102. Name three minerals formed in pegmatites.

A102. Quartz (e.g. Citrine, Amethyst, Beryl), Apatite, Feldspar, Fluorite, Spodumene, Topaz and Tourmaline, are some.

Q103. How can a negative crystal be distinguished from a solid crystal?

A103. Negative crystals look more transparent than solid crystals, and appear lighter in colour than the host crystal.

Q104. True or false? The following synthetic stones appear a red colour when viewed through a Chelsea Filter: Spinel, Ruby, Blue Sapphire, Emerald, Quartz, Topaz, Opal, Peridot.

A104. True.

Q105. What colours do pastes show when viewed through a Chelsea Filter?

A105. Red pastes and some dark blue pastes show red to pinkish red. A dark blue paste coloured with cobalt will show red. Light blue pastes show a greenish colour.

PART ONE - PHYSICAL GEMMOLOGY

Q106. When using a Polariscopes in the dark position, what is the juxtaposition of the polaroids? What is the polariscopes used for in this position? What are the possible effects?

A106. The polaroids are crossed. It is used to determine whether the substance is doubly or singly refractive. The possible effects are:

- a) isotropic - dark no change.
 - b) anisotropic - light to dark four times in 360 degrees of rotation.
 - c) cryptocrystalline - light no change.
 - d) strained isotropic or tabby extinction or anomalous double refraction - light to dark rolling over the stone.
-

Q107. What are the names given to the polarised light rays in uniaxial stones?

A107. Omega is the ray with the constant numerical value of RI, and epsilon is the variable ray.

Q108. Which media are singly refractive?

A108. Liquids, gases, non-crystalline substances, and solid crystals in the isometric system.

Q109. What is birefringence?

A109. Birefringence is the difference between the maximum and minimum RI's measured in a doubly refractive gemstone.

Q110. What are some different types of cabochons? Give an example of each.

- A110.
- a) Simple - Opal, Cat's Eye.
 - b) Double - two very flat pieces cemented together.
 - c) Hollow - a hollowed out cabochon, used for dark material, e.g. Almandine Garnet. Sometimes called a carbuncle.
 - d) Tallow topped - black Opal usually and very flat.
 - e) High cabochon - used to increase optical effects. Limit of height is dictated by aesthetics.

PART ONE - PHYSICAL GEMMOLOGY

Q111. What is ionic bonding?

A111. Where one atom gives up an electron completely to another atom resulting in a positive and a negative ion. The bond between these two unlike charges is ionic bonding.

Q112. What colours are produced by the transition element iron? In which stones is this evident?

A112. Yellow, brown, red, green.
Chrysoberyl, Sapphire, Aquamarine, Spinel, Peridot, Tourmaline.

Q113. What are fancy Diamonds?

A113. These are Diamonds which have a definite shade of colour. Examples are blue, green, brown, red, yellow, pink.

Q114. What is the meaning of the word anhedral?

A114. Anhedral means poor faces showing.

Q115. In simple terms, what are the differences between oxides, carbonates, phosphates and silicates? Name two gemstones as examples of each.

A115. Oxides are generally hard and resistant to acid attack. Some examples are Chrysoberyl, Corundum, Opal, Quartz, Spinel. Carbonates are soft and easily attacked by acid. A few are Calcite, Malachite, Rhodochrosite. Phosphates are also soft but more resistant to acid attack than are carbonates. Apatite and Turquoise are two examples. Silicates are hard and durable. Some are Beryl, Feldspar, Garnet, Jade, Peridot, Topaz, Tourmaline, Zircon.

Q116. Name three gemstones coloured by the transition element vanadium.

A116. Blue Zoisite; the Alexandrite simulated by synthetic Corundum; blue/violet Sapphire, Tsavorite.

PART ONE - PHYSICAL GEMMOLOGY

Q117. Define adamantine lustre.

A117. The highest degree of surface polish achievable on Diamond, Zircon, and Demantoid Garnet.

Q118. What is the characteristic which Diamond and Kyanite have in common?

A118. Both possess directional hardness; i.e. in one direction the hardness is substantially different from the hardness in another direction at right angles.

Q119. How do anisotropic media refract light-rays?

A119. The incident light ray will split into two rays which take different paths and proceed at different velocities. Each refracted ray is plane polarised in planes mutually at right angles. The vibration directions within each plane are rarely at right angles to the direction of travel of the ray. The exceptions to the foregoing are when the incident ray is caused to be refracted along an optic axis. In this case the ray is not polarised and it travels in the new direction at a constant velocity.

Q120. Briefly and simply explain the powder method of X-ray analysis.

A120. A beam of monochromatic X-rays is passed through a small quantity of powdered mineral. The X-rays are diffracted by the powder and are received on a special film strip. The result on the film is a series of arcs on either side of the main beam and is called the X-ray spectrum. The spectrum is unique for the particular mineral being examined.

Q121. Which stones fluoresce when the crossed filter technique is used?

A121. Those with chromium-rich impurities, e.g. natural and synthetic Ruby, natural and synthetic red Spinel, pink Topaz, Emerald, Alexandrite. If iron is present, however, fluorescence will be inhibited.

PART ONE - PHYSICAL GEMMOLOGY

Q122. When using a spectroscope to examine gemstones, is absorption the only phenomenon observed? Give an example to illustrate your answer.

A122. No. Some stones such as Ruby, for example, owe their colouring to the isomorphous replacement of atoms in the crystal lattice by chromium. If the replacement is small scale, i.e. not an excess of chromium and if there is an absence of iron, the narrow lines in the red part of the spectrum are likely to be seen as bright emission lines rather than the usual dark absorption lines.

Q123. Name and briefly describe the three types of rock metamorphism.

A123. Contact metamorphism is where there is heat and some pressure due to the proximity of the magmatic intrusion. Regional metamorphism is heat and pressure as a function of depth within the earth's crust. Cataclastic is metamorphism due to heat and pressure caused by violent earth movements.

Q124. Should brilliant cut stones be examined on a polariscope in a table up or table down position?

A124. In a well cut brilliant stone all light entering the stone through the table is totally reflected back out of the stone. Thus when examining a brilliant cut stone on a polariscope it should be placed so that the source light is incident on any but the table facet.

Q125. What factors determine the weight of a brilliant cut gemstone?

A125. The SG of the material, the diameter and the proportions.

Q126. What will be seen on a refractometer scale when the colour of the light source is white?

A126. A narrow spectrum predominantly blue-green will be seen together with a quite narrow yellow band. The reading should be taken at the point where the yellow and the blue-green meet.

PART ONE - PHYSICAL GEMMOLOGY

Q127. Name one method of determining RI other than by use of a refractometer.

A127. Three of the most common are the Becke Line method, the immersion method and by the use of a calibrated microscope.

Q128. What is dark field illumination?

A128. This is a technique for examining gemstones using a microscope. The stone is illuminated indirectly from below rather than directly from on top. This type of illumination provides a better contrast of light reflection from inclusions and the background colour of the stone, making the inclusions more visible. than when observed under direct illumination.

Q129. Why are loupes made with x10 magnification?

A129. This is the best compromise. A magnification less than the power of 10 does not show sufficient detail to be of use to the observer. A magnification of greater than 10 means a focal length so short as to make hand holding for steady focus difficult.

Q130. Name some gemstones which typically have negative crystal inclusions.

A130. Almandine Garnet, Beryl, Corundum, Diamond, Fluorite, Spinel.

Q131. How should a polariscope be used to test for anomalous double refraction?

A131. Firstly, turn the upper plate, the analyser, for minimum light to show. Secondly, turn the stone to allow maximum light transmission. Thirdly, turn the analyser and observe the effect. If the light coming through the stone increases as the analyser is turned, this indicates ADR in the stone.

PART ONE - PHYSICAL GEMMOLOGY

Q132. What is the crossed filter technique and what is it used for?

A132. Composite white light transmitted through a flask of copper sulphate in liquid solution will have all of the red light absorbed, the only colours transmitted being green, blue and violet. If rays of this latter light are focused on a gemstone and if the gemstone is observed through a Chelsea Filter, one of two possible colours will be seen, depending on whether or not the stone fluoresces under the stimulus of the incident green/blue/violet light. If the stone appears dark, no fluorescence is occurring. If, however, the stone appears red, it must be fluorescing (because all of the possible incident red light has been absorbed in the copper sulphate solution). Thus this is a test for fluorescence in gemstones.

Q133. What are the practical limitations on the use of a standard refractometer?

A133. Firstly, stones with an RI of greater than 1.81 cannot be tested. The RI of the stone under test must be less than that of the RI liquid which in turn must be less than that of the glass hemisphere in the refractometer. Secondly, the stone must have at least one and preferably two polished faces which can be made to contact the glass of the refractometer. Thus some set stones may not be able to be tested unless they are removed from the setting.

Q134. What will be the colour of a substance in the following four cases?

- a) All wavelengths of light pass equally through the substance.
- b) All wavelengths of light will be completely absorbed.
- c) All wavelengths of light will be reflected equally.
- d) Some wavelengths of light will be absorbed and certain ones will be reflected.

A134. a) Colourless.
b) Black.
c) Opaque and colourless.
d) Coloured according to the transmitted wavelengths.

PART ONE - PHYSICAL GEMMOLOGY

Q135. When using a polariscope why should more than one facet of a gemstone be tested? For absolute certainty, how many facets should be tested?

A135. Because the facet under test may be perpendicular to an optic axis in an anisotropic stone, in which case the stone will appear to be singly refractive. Generally two facets tested will suffice, however it should be remembered that biaxial stones have two optic axes. Thus it is possible that the two facets tested are perpendicular to these two optic axes. For absolute certainty three facets should be tested.

Q136. What are X-rays? How may these be used in gemmology?

A136. X-rays are electromagnetic waves of high energy at about one thousandth of the wavelength of visible light. In gemmology they may be used in two ways. One is in a manner similar to that of UV testing, in that they can cause luminescence in some gemstones. This is a diagnostic aid. The other is that they can penetrate materials which absorb or reflect visible light. This penetrative effect can be used to show a reaction on photographic film or by fluorescence of another material. This effect can also be diagnostic in gemmology.

Q137. What is the convention for naming the optic sign of a biaxial crystal?

A137. In measuring the three polarised rays alpha, beta and gamma, where the RI of beta is closer to that of alpha than it is to gamma, the stone is positive. Similarly where the RI of beta is closer to that of gamma than it is to alpha, then the stone is negative.

Q138. A stone weighs 1.2 grams. How many carats is this?

A138. 6 carats. A carat is 200 milligrams (one fifth of a gram).

Q139. What is isomorphic replacement? Give an example.

A139. Isomorphic replacement is replacement of one element by another of similar valency and size in the chemical composition of a mineral. A classic example is Garnet where the many different varieties such as Demantoid, Andradite, Spessartine, Grossular etc., all exist because of this phenomenon. Other examples are Peridot and Tourmaline.

PART ONE - PHYSICAL GEMMOLOGY

Q140. What is pleochroism?

A140. Pleochroism is defined as the differential selective absorption of the polarised rays in doubly refractive stones. Expressed in more basic terms it is the phenomenon of the colour effect caused by the combinations of the different polarised light waves in doubly refractive stones.

Q141. What is the difference between pleochroism, dichroism and trichroism?

A141. Pleochroism is the general term describing the coloured effect seen in some doubly refractive stones. Dichroism is the two coloured effect seen in some uniaxial stones. Trichroism is the three coloured effect seen in some biaxial stones.

Q142. Bondings produce compounds. What are the major classifications of compounds?

A142. Oxides which are a combination of metal and oxygen. Metallic salts which fall into three sub categories of carbonates (metal and carbonic acid), fluorides (metal and hydrofluoric acid), and silicates (metal and silicic acid).

Q143. What colours are produced by the transition element cobalt and in which stones?

A143. Cobalt produces pink and red in non-gem minerals. It rarely occurs naturally in gem minerals at all. It produces blue in synthetic Spinel and also in some glass.

Q144. Name three gem minerals formed in acid igneous rock.

A144. Beryl, Feldspar, Garnet, Quartz, Topaz, Tourmaline, Zircon.

PART ONE - PHYSICAL GEMMOLOGY

Q145. What is a halo inclusion?

A145. A halo inclusion is a solid crystal surrounded by stress cracks. If the included crystal is a Zircon (or any other containing uranium) The stress cracks will slowly grow with the passage of hundreds of years. Brown stress cracks looking like the wings of an insect are caused by Zircon. A black-green Uraninite inclusion will cause the stress cracks to appear as an aureole, the whole looking like a flower.

Q146. Describe the construction of a dichroscope.

A146. A dichroscope consists of a cleavage rhomb of optically pure Calcite mounted in a tube. A glass prism is cemented at each end of the rhomb. The tube has an eyepiece at one end and a square aperture at the other end.

Q147. What are the uses of polarised light in gemmology?

A147. a) to detect isotropic substances.
b) to detect pleochroism.
c) to detect optic character and optic sign.

Q148. Name some gemstones which show the chromium spectrum.

A148. Alexandrite, Emerald, Chrome Diopside, Chrome Grossular Garnet, Demantoid Garnet, Pyrope Garnet, Jades, Ruby, Pink Topaz.

Q149. What is polymorphism?

A149. Polymorphism is the crystallising in more than one system; e.g., carbon crystallises in the hexagonal system as Graphite and in the isometric system as Diamond.

Q150. What conditions must exist to be able to observe pleochroism in a gemstone?

A150. Firstly the stone must be coloured. Secondly it must be anisotropic, i.e. doubly refractive. Thirdly it must be observed in a direction other than along an optic axis. Note that white source light will produce the best effect.

PART ONE - PHYSICAL GEMMOLOGY

Q151. Name two minerals formed in intermediate igneous rocks.

A151. Ruby, Sapphire, Zircon.

Q152. Name some gemstones which may typically have Zircon haloes included.

A152. Australian Sapphire, Sri Lankan Sapphire, Sri Lankan Ruby, Kornerupine, Almandine Garnet.

Q153. A pleochroic gemstone is observed with a dichroscope looking along an optic axis. As the stone is rotated about this axis what colour change will be observed?

A153. None. The optic axis is the direction of single refraction and no pleochroic effect occurs.

Q154. How many rays of polarised light can be seen in a biaxial stone using a dichroscope?

A154. Three, but only two can be seen concurrently.

Q155. Name some gemstones which show the ferric iron spectrum.

A155. Yellow-green, green, and blue natural Sapphire. Brown and yellow Chrysoberyl. Aquamarine. Yellow Orthoclase.

Q156. Referring to question 142, name two gemstones in each of the categories of oxides, carbonates and silicates.

A156. Chalcedony, Corundum, Opal and Quartz are all oxides. Azurite, Calcite, Malachite and Rhodochrosite are all carbonates. Within the silicate group there are no less than 60. A few of these are Andalusite, Benitoite, Beryl, Diopside, Epidote, the Feldspars, the Garnets, Iolite, the Jades, Peridot, Sodalite, Spodumene, Topaz, Tourmaline, Zircon, Zoisite.

PART ONE - PHYSICAL GEMMOLOGY

Q157. Can pleochroism be seen with the naked eye?

A157. In some cases, yes. Andalusite is an example. Generally, a dichroscope needs to be used.

Q158. Copper, iron and manganese separately cause colouring in some minerals. Name one mineral so coloured for each of these three transition elements, and the colour produced.

A158. Copper produces green in Malachite, blue in Azurite, greenish-blue in Chrysocolla, green in Diopside, and sky-blue in Turquoise. Iron produces red in Almandine Garnet and green in Peridot. Manganese causes red in Rhodonite and Rhodochrosite. Manganese also produces orange in Spessartite Garnet.

Q159. In crystallography, what are the seven basic unit cells?

A159. Isometric or cubic, tetragonal, hexagonal, trigonal, orthorhombic, monoclinic, triclinic.

Q160. Briefly describe an orthorhombic unit cell.

A160. It has three sides all unequal, and all angles are at ninety degrees. It has the shape of a matchbox.

Q161. What does cryptocrystalline mean?

A161. It means large numbers of submicroscopic crystals. The word is synonymous with microcrystalline.

PART ONE - PHYSICAL GEMMOLOGY

Q162. Name at least four techniques for treating gemstones. Give an example of each.

-
- A162. a) Heating. Blue Sapphire is produced by heating to lighten very dark Corundum and to remove "silk". Citrine is produced by heating Amethyst.
b) Bleaching. White, cream and pink Pearls are produced by bleaching dark and/or spotted Pearls.
c) Dyeing. Red Coral is produced by dyeing orange or pale Coral. Dark, evenly coloured Lapis Lazuli is produced by dyeing light coloured and partly Calcite-included Lapis Lazuli.
d) Impregnation. Emerald is improved by adding colourless wax, oil, plastic etc. to hide fractures. Black Opal is produced by sugar-treating porous Opal.
e) Irradiation. Golden Beryl is produced by irradiation of colourless or very pale blue Beryl. Yellow to orange-brown Topaz is produced by irradiating almost all Topaz.
f) Surface coating. Occasionally waxes, varnishes and plastics are used to improve the surface appearance of Beryl and Lapis Lazuli.
-

Q163. Name three gem minerals formed in basic igneous rocks.

A163. Diamond, Peridot, Pyrope, Ruby, Sapphire, Spinel.

Q164. What are zonal inclusions?

A164. Zoning is straight growth lines of bands with definite angles. When present, this is an indication that the stone may be natural.

Q165. What is the principle of operation of the hydrostatic balance?

A165. An object fully immersed in a liquid experiences an upward force, equal to the weight of the displaced liquid. By comparing the weight of the object in air and in the liquid, the specific gravity can be calculated.

Q166. What does amorphous mean?

A166. It means non-crystalline and without form.

PART ONE - PHYSICAL GEMMOLOGY

Q167. Give some examples of solid crystal inclusions in gemstones.

A167. Diamond crystal in Diamond; Spinel in Ruby; Pyrite in Quartz;
Rutile in Quartz; Tourmaline in Quartz; Zircon in Sapphire;
Zircon in Garnet.

Q168. What is the magnification range of microscopes generally used for
gemmological work?

A168. 10x to 80x. 40x is that most commonly used.

Q169. In a perfectly cut, brilliant Diamond what percentage of light
entering the table is refracted out of the pavilion facets?

A169. None. Theoretically all light is totally internally reflected to
appear at the crown facets.

Q170. What colours do the following stones fluoresce under long wave
and short wave UV? Garnet, natural blue Spinel, Quartz?

A170. All of these stones are inert under the stimulus of UV.

Q171. Name at least five gem minerals formed in contact metamorphic
rocks.

A171. Andradite, Axinite, Diopside, Epidote, Fluorite, Grossular
Garnet, Iolite, Peridot, Sapphire, Scapolite, Topaz, Tourmaline,
Zoisite.

Q172. Inclusions are formed at three different times in relation to a
crystal's growth. One such time relationship is prior to the
growth of the crystal. What is the name given to this? Give some
examples.

A172. Preformed or "ready-made" crystals are called protogenetic, and
can only be minerals. Some examples are actinolite rods in Ural
Emeralds; Apatite in Sri Lankan Garnets, Sapphire and Spinel;
Biotite flakes in Emeralds.

PART ONE - PHYSICAL GEMMOLOGY

Q173. Name not less than twelve characteristics to be observed when using a 10x loupe and/or the naked eye.

A173. Cut; diaphaneity; colour; pleochroism; dispersion; polish; surface marks; facets and facet edges; lustre; cleavage; parting; back facet doubling; doublets and triplets; inclusions; fracture; interference, e.g. asterism, chatoyancy, adularescence, iridescence.

Q174. Complete the sentence from the alternatives offered. The higher the critical angle the:
a) higher the dispersion
b) greater the refraction
c) greater the reflection
d) lower the RI.

A174. d) The higher the critical angle, the lower the RI.

Q175. Name some gemstones which show the ferrous iron spectrum.

A175. Almandine, Peridot, Sinhalese, blue Spinel, Diopside, Iolite.

Q176. Name three minerals formed in regional metamorphic rocks.

A176. Beryl, Chrysoberyl, Garnet, Kyanite, Sapphire, Spinel.

Q177. Inclusions are formed at three different times in relation to the time of crystal growth. One such time relationship is during the growth of the crystal. What is the name given to this? Give some examples.

A177. Syngenetic inclusions develop simultaneously with the growing host and are enclosed in it. Examples are Biotite in Sri Lankan Sapphire, Byssolite in Demantoid, Olivine in Diamond, Tourmaline in Quartz, Zircon in Corundum. Also in this category are finger-prints, two and three phase inclusions, twin lamellae and zonal growth.

PART ONE - PHYSICAL GEMMOLOGY

Q178. What precautions must be observed when using a hydrostatic balance?

A178. a) ensure that the stone is clean.
b) zero check before every weigh and at the conclusion
c) weigh dry before weighing wet.
d) ensure that the stone is totally immersed in the fluid.
e) ensure that no air bubbles attach to the immersed stone.
f) ensure the glass doors are closed when weighing.
g) lever must be in neutral when stones are moved on or off the balance.
h) do not touch the zero knob.

Q179. What is the particular characteristic of light behaviour which is used principally in the design of a refractometer?

A179. Total internal reflection of those rays with angles greater than that of the critical angle.

Q180. Name two gemstones which show the manganese spectrum.

A180. Rhodonite, Rhodochrosite, and the Malaya or P.A.S. Garnet isomorphous series.

Q181. What is a pegmatite?

A181. Pegmatite is a coarse grained Quartz-Feldspar igneous rock. Pegmatites have a high carbon and water vapour content.

Q182. Inclusions are formed at three different times in relation to the time of the crystal growth. One such time relationship is after the completion of the crystal growth. What is the name given to this? Give some examples.

A182. These are called epigenetic inclusions. Examples are silk in Corundum, iron-stained fissures, rainbow interference in cracks.

PART ONE - PHYSICAL GEMMOLOGY

Q183. A gemstone is observed with a dichroscope, and no colour change is noted. The stone is therefore singly refractive - true or false? Give reasons for your answer.

A183. Not necessarily true. A singly refractive stone will not give a pleochroic effect. However the stone may be a colourless one, or it may have been observed down an optic axis, or the degree of pleochroism may be so weak that it could not have been detected.

Q184. What is meant by double refraction?

A184. When a light ray enters a doubly refractive substance,, e.g. all crystals except those in the isometric system, the light becomes polarised into two separate rays which take separate paths, travel at different velocities and which have different RI's.

Q185. Name some gemstones which show the cobalt spectrum.

A185. No naturally occurring gemstone is coloured by cobalt. Cobalt does colour some non-gem minerals red. Cobalt produces blue colour in synthetic Spinel, some glass and some plastics.

Q186. Name some minerals found in gem gravels.

A186. Chrysoberyl, Diamond, Garnet, Quartz, Ruby, Sapphire, Spinel, Tourmaline, Zircon. Note: Gem minerals of low hardness or poor tenacity such as Beryl, Peridot and Topaz are also found in gem gravels but quality and size are usually not good.

Q187. Inclusions are generally described by state and appearance. Give examples of these.

A187. State - solid, liquid or gas or any combination of these.
Appearance - solid positive crystals; internal cavities; cracks and fractures; growth phenomena.

Q188. What is the advantage of dark field illumination?

A188. It offers better viewing inside the stone because it eliminates reflected light from the facets.

PART ONE - PHYSICAL GEMMOLOGY

Q189. What does pseudomorphic mean?

A189. Pseudomorphic means false form. A mineral which has adopted an external form other than that of its normal habit by copying for example the shape of a pre-existing crystal or arganic structure is a pseudomorphic form.

Q190. In a doubly refractive, uniaxial stone, what and where is the optic axis?

A190. The optic axis is the direction of single refraction. It is always in the direction of the C axis.

Q191. What colours are produced by the transition element vanadium? Give an example of a stone so affected.

A191. Vanadium produces red and green. Synthetic Corundum imitating Alexandrite is an example.

Q192. What is a pegmatite dyke? Why is it important?

A192. A pegmatite dyke is a wall-like intrusion which cuts across bedding planes or other layered strata of country rock. Pegmatite dykes grow from a crack or fissure through the layers which allow magma to flow to lower levels. Pegmatite dykes are one of the best producers of gem materials and are second only to the diamond pipes and alluvial basins in this respect.

Q193. Why do some Emeralds, e.g. those from Colombia and Siberia, appear red when viewed through a Chelsea filter?

A193. Firstly, the green transmitted by the Emerald is at a wavelength different from that which will be transmitted by the filter. Secondly, the chromium in the Emerald gives a red which is at a wavelength close to that transmitted by the filter.

Q194. In a doubly refractive uniaxial stone, in which directions will polarised and non-polarised light be seen?

A194. Non-polarised light will be seen only in the direction of the optic axis. Polarised light will be seen in all other directions.

PART ONE - PHYSICAL GEMMOLOGY

Q195. Name one gemstone which will show the uranium spectrum.

A195. Zircon. Note that as the type of Zircon regresses from high to low the intensity of the spectrum diminishes to the point of being almost non-existent in the low types.

Q196. What colours are produced by copper? Name one gemstone so coloured.

A196. Copper produces blues and greens. Malachite and Azurite are coloured by copper.

Q197. What is the principle of operation of a reflectivity meter?

A197. The reflectivity of the surface being examined is the ratio of the reflected ray to the incident ray. The intensity of both rays can be measured and converted to an electrical current. Thus measurement of the currents and comparison of these is representative of the reflectivity of the surface.

A198. In which crystal systems does one find uniaxial stones?

A198. Those crystal systems whose names end with the letters "al" have uniaxial stones. These are tetragonal, hexagonal and trigonal.

Q199. What is believed to be the cause of absorption spectra in Diamond?

A199. Basically it is believed to be caused by distortions in the crystal lattice.

Q200. In doubly refractive uniaxial stones there are two polarised light rays (except along the optic axis). Are the RI's of these two rays constant?

A200. One is constant regardless of direction. The other changes with direction.

PART TWO - APPLIED GEMMOLOGY

Q1. In which stones are Parasite crystals found as inclusions?

A1. Parasite crystals are found as inclusions only in Muzo Emeralds from Colombia, South America.

Q2. What characteristics are considered to be important when assessing the value of a diamond?

A2. The important characteristics are known as the four "C's". They are Clarity, Colour, Carat, and Cut.

Q3. Which stones have the following characteristic inclusions? "Needle-like silk in parallel threads intersecting at sixty degrees and in a plane perpendicular to the 'C' axis."

A3. Sapphire and Ruby.

Q4. Following are six gemstones and six characteristics. Match a characteristic with a gemstone.

Demantoid Garnet Trillings
Apatite Centipede inclusions
Moonstone Byssolite horsetail inclusions
Chrysoberyl Green Tourmaline inclusions
Aventurine Quartz A very low birefringence
Kashmir Sapphire Spangles

A4. Demantoid Garnet Byssolite horsetail inclusions
Apatite A very low birefringence
Moonstone Centipede inclusions
Chrysoberyl Trillings
Aventurine Quartz Spangles
Kashmir Sapphire Green Tourmaline inclusions

Q5. What are the names given to the two end members of the Peridot isomorphous series? Name the elements responsible.

A5. The end member caused by magnesium is called Forsterite. The other end member known as Fayalite is caused by iron.

PART TWO - APPLIED GEMMOLOGY

Q6. Name two stones synthesised to simulate Alexandrite. Also, name another means of producing an imitation Alexandrite.

A6. Spinel and Corundum are synthesised to simulate Alexandrite. One method of imitating Alexandrite is to manufacture a Quartz doublet cemented with a specially coloured adhesive. Synthetic Alexandrite is also manufactured as such.

Q7. Which ornamental stone is imitated by synthetic Spinel, and how may it be detected?

A7. Lapis Lazuli is imitated by synthetic Spinel. As the colouring agent is cobalt, the material will appear bright red when viewed through the Chelsea filter. True Lapis will appear a dull red when similarly viewed.

Q8. What are Lechleitner Emeralds?

A8. Lechleitner Emeralds are poor-grade Beryls coated with synthetic Emerald by the hydrothermal process. The Emerald growth follows the structure of the seed Beryls.

Q9. The butterfly inclusion is found in which stones? What is it?

A9. It is found in some Australian and some Sri Lankan Sapphires. The inclusion is usually a Zircon crystal with two or more iron-stained or liquid feather haloes emanating from the zircon, the whole inclusion looking like a butterfly.

Q10. Select from the four possible answers given, the one which best completes the sentence: The interference figure for Quartz is the same for all varieties except a) Rose Quartz, b) Amethyst, c) the cryptocrystalline group, d) none of these.

A10. The correct answer is b) Amethyst.

Q11. How does YAG react to X-radiation?

A11. YAG shows a yellow fluorescence when subjected to X-rays. It reacts similarly when subjected to long wave UV.

PART TWO - APPLIED GEMMOLOGY

Q12. By using a spectroscope, how may Chrysoprase be differentiated from green Chalcedonies?

A12. Chrysoprase is unique in that it owes its colour to nickel. By using the spectroscope a narrow nickel absorption band at 632 nm may be observed if the stone being examined is indeed Chrysoprase. It is also of value to note that if a strong chromium doublet in the red is observed, the specimen is probably Chrome Chalcedony.

Q13. What synthetic is used to imitate Moonstone and how may it be detected?

A13. Synthetic Spinel is used to imitate Moonstone. Providing that RI and SG tests can be taken, differentiation is simple because the constants are substantially different.

Q14. Answer the following questions in relation to Aquamarine.
a) Will it fluoresce and why?
b) What inclusions may be seen?
c) What does Maxixe mean?

A14. a) No, because of the presence of iron.
b) Parallel tubes; Negative crystals; "Chrysanthemums".
c) Maxixe, (pronounced ma-chi-chi) is a blue Beryl which when exposed to a normal light loses its colour, but which under a subdued light exhibits a distinct dichroic effect. This type of beryl comes from the Maxixe mine in Brazil.

Q15. What is the proof that a stone is Emerald and not common Beryl?

A15. When examined with the spectroscope, Emerald will show the chromium spectrum. This is the accepted standard in the UK and in Australia. In the USA the standard is more qualitative in that the criterion is the colour of the stone.

PART TWO - APPLIED GEMMOLOGY

Q16. In the following table, match a gemstone with the most likely characteristic.

Muzo Emerald	Pyrites inclusions.
Lapis Lazuli	SR, RI = 1.60, UV shows green.
Paste	Inclusions intersecting at 60 degrees and perpendicular to the C axis.
Diamond	Brown parisite inclusions.
Ruby	Inclusions intersecting at 70 and 110 degrees.
Almandine Garnet	Trigons.

A16. Correct relationships are:

Muzo Emerald	Brown parisite inclusions.
Lapis Lazuli	Pyrites inclusions.
Paste	SR, RI = 1.60, UV shows green.
Diamond	Trigons.
Ruby	Inclusions intersecting at 60 degrees and perpendicular to the C axis.
Almandine Garnet	Inclusions intersecting at 70 and 110 degrees.

Q17. Name three types of Feldspar which form an isomorphous series, and identify the major chemicals which cause these.

A17. Orthoclase	potassium aluminium silicate
Albite	sodium aluminium silicate
Anorthite	calcium aluminium silicate

Q18. Jade occurs in two varieties. What are the names of these varieties, and to which mineral groups and crystal systems does each belong?

A18. Jadeite is one variety. It belongs to the pyroxene group and forms in the monoclinic system. The other variety is Nephrite. It belongs to the amphibole group and also forms in the monoclinic system.

Q19. How may Lechleitner Emeralds be detected?

A19. Lechleitner Emeralds may be detected as follows:
a) Lines and/or flaws occur throughout the layer of the synthetic material.
b) When immersed in liquid, the stones appear pale in the centre with a darker green narrow outline.
c) Polishing sometimes reveals the seed Beryl.
d) Visible surface crazing and/or cracking.

PART TWO - APPLIED GEMMOLOGY

Q20. What is reconstituted Coral and how may it be detected?

A20. Reconstituted Coral is small pieces of Coral ground up and bonded with synthetic resin. Under UV it fluoresces a brilliant yellow orange.

Q21. When doing an RI, how many facets need to be tested and why?

A21. Two facets should be tested. The reason is that some doubly-refracting stones are cut such that the table is perpendicular to an optic axis. This means that when the table facet is placed on the refractometer glass surface, there will be only one set of RI readings obtained.

Q22. What are the major classifications of Feldspar? Give one gem variety of each and name the crystal system of each.

A22. Plagioclase; Oligoclase (Sunstone or Aventurine); Triclinic
Plagioclase; Labradorite; Triclinic
Orthoclase; Moonstone; Monoclinic
Microcline; Amazonite; Triclinic.

Q23. There are no less than 30 known Jade simulants. Name as many as you are able.

A23. Some Jade simulants are: Agalmatolite; Agate; Amazonite; Antigorite; Aragonite; Aventurine Quartz; Beryl; Bowenite; Buddstone; Calcite; Californite; Chrysoprase; Fluorite; Glass; Hydrogrossular Garnet; Idocrase; Jasper; Malachite; Opal; Pectolite; Plasma; Plastic; Prase; Prehnite; Pseudophite; Ricolite; Saussurite; Serpentine; Smithsonite; Talc; Verd Antique; Verdite; Vesuvianite; Williamsite.

Q24. Which gemstones are manufactured on a large commercial scale?

A24. Corundum; Spinel; Emerald. Also the Diamond simulants e.g. Strontium Titanate; Cubic Zirconia; and the synthetic Garnets such as YAG and GGG.

PART TWO - APPLIED GEMMOLOGY

Q25. Fingerprint or feather inclusions are common in which gemstones?

A25. Fingerprint or feather inclusions are common in Ruby, Sapphire, Emerald, Aquamarine, Topaz.

Q26. What chemical do Orthoclase and Microcline Feldspar have in common?

A26. Potassium.

Q27. Which of the following alternatives is the correct answer?

Prasiolite is:

- a) A variety of Chrysoprase
- b) Heat-treated Amethyst
- c) An end member of an isomorphous series
- d) Cryptocrystalline

A27. b) Heat-treated Amethyst.

Q28. What is Jet? Where is it found?

A28. Jet is fossilised wood. It is found mainly in Yorkshire, United Kingdom.

Q29. Other than Copal, what are some Amber simulants?

A29. Kauri gum, Bakelite, Polystyrene, Perspex, Casein, Celluloid, Glass.

Q30. The sky-blue Zircon is the only Zircon commercially simulated. What is the simulant stone? How may it be detected?

A30. Synthetic blue Spinel is the simulant. It may be detected as the Spinel is singly refractive, whereas Zircon is doubly refractive. Also, when viewed with the Chelsea Filter the synthetic Spinel shows orange whereas the Zircon shows green. Under LW UV the Spinel will fluoresce red and bluish-white under SW UV, whereas the Zircon will fluoresce a mustard colour under LW UV.

PART TWO - APPLIED GEMMOLOGY

Q31. Tourmaline is classified into three main groups. What are these?

A31. 1. Alkali-rich. Colours are red, green, colourless.
2. Iron-rich. Colours are dark blue , blue/green, black.
3. Magnesium-rich. Colours are yellow/brown, brown/black, colourless.

Q32. What is vegetable ivory?

A32. Vegetable ivory is the hard white kernel of the corozo palm tree nut (*Phytolophas macrocarpa*) grown in South America.

Q33. What are the observations and tests which will positively identify a stone as Zircon?

A33. 1. Back facet doubling.
2. High dispersion.
3. Mustard-coloured fluorescence under LW UV.
4. The Zircon spectrum is best described as a strong line at 653 nm and up to 40 lines across the whole spectrum. Note that in heat treated Zircon these lines are less apparent.

Q34. Select the most appropriate answer below to the following question: What is Morion?

- a) A dendritic variety of Quartz.
 - b) Dark smoky Quartz.
 - c) Heat-treated Citrine.
 - d) Colourless Rock Crystal.
-

A34. b). Dark smoky Quartz.

Q35. Which Garnet variety may have included needles intersecting at 70 and 110 degrees? Select one of the following:

- a) Grossular var. Uvarovite
 - b) Andradite var. Demantoid
 - c) Grossular var. Hessonite
 - d) Almandine
-

A35. d) Almandine

PART TWO - APPLIED GEMMOLOGY

Q36. Name five inclusions found in Diamond.

A36. Some are Olivine, Garnet, Chrome Spinel, Chrome Enstatite, Chrome Diopside, Graphite, Diamond, Quartz.

Q37. What colour of Sapphire will not show dichroism?

A37. Colourless Sapphire will not show dichroism. Also it is very difficult to detect dichroism in yellow Sapphire.

Q38. In which geological formations are Zircons found?

A38. In magmatic rock and gem gravels.

Q39. Is the cause of colour in Peridot allochromatic or idiochromatic?

A39. Ferrous iron causes the colouring in Peridot. By removing the iron the stone would no longer be a Peridot. Therefore it is idiochromatic.

Q40. What is a significant factor which determines how a Tourmaline should be cut?

A40. Dichroism is a prominent characteristic of Tourmaline. Light travelling in the direction of the vertical crystallographic axis is always deeper in colour than light travelling at right-angles to the vertical axis. Thus pale coloured stones should have the table facet cut in a plane at right-angles to the vertical axis. Similarly dark stones should be cut with the table parallel to the vertical axis.

Q41. What are the main colours of Apatite?

A41. Colourless, pink, yellow, green, blue, violet.

PART TWO - APPLIED GEMMOLOGY

Q42. What are the basic differences between Type 1 and Type 2 Diamonds?

A42. Type 1.
Nitrogen up to 0.25%
Will transmit UV down to 330 nm then becomes opaque
Is a non-conductor of electricity
Is a good heat conductor

Type 2.
Nitrogen not more than 0.001%
Will transmit UV down to 220 nm then becomes opaque
Type 2B may be a semi conductor of electricity
Is a very good heat conductor (about five times that of copper)

Q43. What is Beryl Glass?

A43. Beryl Glass is fused Beryl. As such it loses its crystalline structure in the heat process and becomes isotropic. As a further consequence of the fusing, the RI, SG and hardness factors all drop to a lower figure.

Q44. How may Chrysoberyl cat's eye be differentiated from Quartz cat's eye?

A44. Both are similar in colour but the Chrysoberyl has a much sharper ray. Also, the SG and RI of Quartz are much lower than those of Chrysoberyl.

Q45. What is the chemical which forms dendritic inclusions in Moss Agate?

A45. Manganese Oxide.

Q46. Name four typical inclusions found in corundum.

A46. Some are:

a) Silk (Rutile) in three sets of parallel lines intersecting at 60 degrees
b) Zircon surrounded by haloes
c) Corundum
d) Haematite in hexagonal form
e) Garnet
f) Mica
g) Iron stains

PART TWO - APPLIED GEMMOLOGY

Q47. What will be observed when Andalusite is examined with a dichroscope?

A47. Andalusite is strongly trichroic. The colours of yellow, green and red will be seen by observing the stone in different directions.

Q48. Name four geographic locations of Peridot.

A48. The major known locations are Isle of St. John in the Red Sea, Norway, Brazil, Burma, Queensland, U.S.A., Hawaii.

Q49. What is the optic character of Corundum?

A49. Uniaxial negative.

Q50. If a blue stone being examined with a dichroscope showed three distinct colours of pale yellow, light blue, and dark violet blue, what is the stone most likely to be?

A50. The stone is most likely to be Iolite.

Q51. What is the difference between Aventurine Glass, Goldstone, Aventurine Feldspar, and Aventurine Quartz?

A51. Aventurine Glass and Goldstone are the same thing; a paste imitation of reddish-brown Aventurine made by including flecks of copper in the glass. Aventurine Feldspar is Oligoclase (sometimes called Aventurine or Sunstone), belonging to the triclinic system and the isomorphous series of albite and anorthite. Aventurine Quartz is quartzite. Due to the presence of green mica and/or reddish iron minerals it exhibits an iridescent spangled effect.

Q52. What is Zerfass Emerald?

A52. This is a synthetic Emerald produced by the German firm Zerfass. The synthetic Emerald is grown by the "flux melt" method.

PART TWO - APPLIED GEMMOLOGY

Q53. What is the stone which is almost inert under LW UV, but fluoresces a bright bluish white under SW UV?

A53. Colourless synthetic Spinel. (N.B. Once you have seen this in the laboratory you will not easily forget it because it is quite distinctive.)

Q54. What is the stone which is almost inert under LW UV, but fluoresces a dull deep blue under SW UV?

A54. Synthetic white Sapphire.

Q55. Briefly describe the Czochralski method of synthesising gemstones. Name two stones produced by this method.

A55. The Czochralski or pulled method is that where a seed crystal is dipped into the molten source material and slowly pulled out, the crystal growing on the seed in the process of pulling. Ruby, Alexandrite (Chrysoberyl var.), YAG, Scheelite, and Lithium Niobate are produced by this method.

Q56. What is a trigon? Why is it of significance?

A56. A trigon is a triangular depression on the surface of a Diamond. It is at 180 degrees' rotation to the octahedral face. Presence of one or more trigons is proof positive that the stone is Diamond and not a simulant or synthetic.

Q57. Do Garnets fluoresce under UV?

A57. The Grossular group i.e. Hessonite, Hydrogrossular, Grossular and Tsavorite, fluoresce an orangey colour. All other Garnets are inert.

Q58. If the Emerald you were examining under the microscope had two phase inclusions shaped like commas, what would be its country of origin?

A58. It most likely would have come from India.

PART TWO - APPLIED GEMMOLOGY

Q59. Which of the following pairs of minerals belongs to the Plagioclase Feldspar group?

- a) Orthoclase; Bytownite
- b) Moonstone; Amazonite
- c) Sunstone; Labradorite
- d) Perthite; Prehnite

A59. c) Sunstone; Labradorite

Q60. In which crystal system does Chrysoberyl occur? What type of twinning is common in Chrysoberyl?

A60. Chrysoberyl crystallises in the orthorhombic system. Trillings which are three intergrown crystals giving the appearance of hexagonal symmetry are a common type of twin.

Q61. Which type of Garnets are frequently found with South African Diamonds?

A61. Pyrope Garnet. Pyrope in quantity is a Diamond indicator.

Q62. What is the mineral used in the manufacture of synthetics to give the "Alexandrite" effect? Name two synthetics commonly used to imitate Alexandrite.

A62. The mineral is vanadium. The most commonly produced Alexandrite synthetics are manufactured from synthetic Spinel and synthetic Corundum.

Q63. Name the usual geological occurrences of Diamond.

A63. Kimberlite pipes and alluvial gravels are the most common occurrences.

Q64. In which crystal system does Tourmaline occur? What are characteristic of tourmaline crystal terminations and prism faces?

A64. Tourmaline crystallises in the trigonal system. The terminations are hemimorphic, and the prism faces have vertical striations.

PART TWO - APPLIED GEMMOLOGY

Q65. What inclusions are common in Paste?

A65. Most common inclusions are swirl marks, spherical and oval bubbles. When viewed with the aid of a microscope, the bubbles have a bright centre and a dark rim.

Q66. Which Garnet is also known as "Transvaal Jade"?

A66. The light green Grossular.

Q67. What variety of gemstone is Morganite? What colour is Morganite in the natural state and what colour is it after heat treatment?

A67. Morganite is a variety of Beryl. In its natural state it is a soft pink to violet colour. After heat treatment it becomes a clear attractive pink.

Q68. Name an Australian source of Emerald.

A68. Emerald is found in Australia at Emmaville and Torrington NSW, and also at Poona WA.

Q69. What is Tsavorite?

A69. Tsavorite is a sub-group of Grossular Garnet. It is vivid to yellow green and contains nickel. It is found in Kenya and Tanzania.

Q70. Simply describe the absorption spectrum of Apatite, and identify the mineral responsible for this.

A70. The spectrum may be simply described as a collection of lines at 580 to 520 nm, invariably in the yellow but not always in the blue/green. It is caused by didymium.

PART TWO - APPLIED GEMMOLOGY

Q71. What inclusions occur in flame fusion synthetics?

A71. a) Curved colour zoning
b) Fine undissolved "dust" along the zonal lines
c) Bubbles in circular, dumb-bell or tadpole shapes.

Q72. To which crystal system do Garnets belong? What are the common forms?

A72. Garnets belong to the cubic (isometric) system. Common forms are rhombic dodecahedron, trapezohedron. Garnets also appear in massive granular and rolled pebble forms.

Q73. In a number of respects Peridot and Sinhalite are similar. Does either fluoresce under UV?

A73. Neither fluoresces under UV.

Q74. What does iron staining look like? In which stones is it commonly found?

A74. Iron staining is brown colouration in healed fracture inclusions. It is commonly found in Ruby and Sapphire.

Q75. What are the main colours of Sinhalite?

A75. Yellow-brown and green-brown.

Q76. What inclusions are found in melt and pulled synthetics?

A76. a) Twisted veils not unlike natural fingerprints
b) Metallic inclusions of platinum and Phenacite crystals
c) Kashan Rubies and Chatham synthetic Sapphires exhibit straight-line bubbles. Kashans also have a peculiar comet-shaped inclusion with a solid head and fan-like tail.

PART TWO - APPLIED GEMMOLOGY

Q77. Comment on the range of colours in which Jade can be found.

A77. Jadeite can be medium yellowish green, yellowish brown, intense medium green, white with green streaks, mauve and red.
Nephrite can be dark green to blackish green, medium to dark greyish green, medium green.

Q78. Finger prints or feathers are common in which gemstones?

A78. This type of inclusion is found in Sapphire, Ruby, Topaz, Emerald, Aquamarine.

Q79. Name three geographical occurrences of Tourmaline including one in Australia.

A79. Sri Lanka, Brazil, Madagascar, Zeehan Tasmania, Flinders Ranges South Australia are some of the many locations where Tourmaline is found.

Q80. Apart from an SG test, how may Cubic Zirconia be differentiated from Diamond?

A80. a) UV radiation for about five minutes will cause CZ temporarily to assume a light brown colour.
b) CZ will fluoresce faint orange-brown under LW UV, and will fluoresce yellow under SW UV.
c) In the moist finger test, Diamond will adhere more often than will CZ.
d) If the stone is not set, place it on a printed page table down. If the printing can be seen the stone is not Diamond.

Q81. Why does synthetic Spinel have a different SG from that of natural Spinel?

A81. Natural Spinel has the chemical formula $MgOAl_2O_3$ which implies equal proportions of magnesium and alumina. In manufacturing synthetic Spinel this 1:1 ratio does not produce good boules. The formula to produce good boules is 1 of MgO and 2.5 of Al_2O_3 . Hence the difference in SG.

PART TWO - APPLIED GEMMOLOGY

Q82. What is the crystal system of Peridot? Typically what is Peridot's habit?

A82. Peridot forms in the orthorhombic system. A well-formed Peridot crystal will have flattened prism terminations, and the prism faces will be vertically striated.

Q83. List the names of at least ten synthetic materials.

A83. Some are: synthetic Spinel, synthetic Emerald, synthetic Corundum, synthetic Diamond, synthetic Alexandrite, YAG, GGG, synthetic Cubic Zirconia, Strontium Titanate, synthetic Quartz, synthetic Rutile, synthetic Opal, Lithium Niobate, synthetic Turquoise, synthetic Lapis Lazuli.

Q84. Although a Diamond is singly refractive, it may exhibit evidence of double refraction. Explain why.

A84. Because of strain in the crystal lattice, extraordinary rays will be produced. If the extent of strain is sufficiently pronounced the strength of extraordinary rays will be sufficient to cause quite pronounced anomalous DR, giving to the unwary observer the appearance of true DR.

Q85. How would you describe the structure, the lustre and surface features, and the fracture of Jadeite and Nephrite?

A85. Jadeite has an interlocking granular structure, a vitreous to greasy and grainy or dimpled surface. Its fracture is described as granular.
Nephrite has an interwoven fibrous structure, a greasy to vitreous surface, and can be chatoyant. Its fracture is described as splintery.

Q86. Name some common inclusions in Peridot.

A86. Peridot from the Isle of St. John have biotite mica flakes. Hawaiian gems have oval and pear-shaped glass drops. These latter should not be confused with bubbles seen in glass, because the inclusions in Peridot will show doubling as will the back facets of the stone. One other characteristic inclusion of Peridot is the water lily.

PART TWO - APPLIED GEMMOLOGY

Q87. What is a generally accepted explanation of how Opal and Agate are formed?

A87. Both are formed by the process of percolating solutions passing through the host rock over many hundreds of years, and depositing secondary minerals in the fissures of the host.

Q88. What are the names given to the shaping processes of Diamond?

A88. In order of activity they are sawing, cleaving, bruting or rhondisting, cross cutting, and brilliant cutting.

Q89. What are the names of some natural forms of glass?

A89. Obsidian, Moldavite, and Tektite.

Q90. In which stones is dispersion best observed? What type of light best facilitates dispersion?

A90. Dispersion is best observed in colourless stones such as Diamond, Zircon, Sphene, and some of the synthetics e.g. Strontium Titanate, Cubic Zirconia, and synthetic Rutile.

Q91. Corundum belongs to which crystal system?

A91. Corundum belongs to the trigonal system.

Q92. Briefly and simply, how is Cubic Zirconia produced?

A92. CZ is manufactured by what is known as the "skull" method. Powdered Zirconia is heaped in a pile inside a specially constructed radio frequency oven. This RF oven melts the powder at around 2300 degrees Celsius. However the surrounding pile is not all melted as the outside of the pile is cooled by water circulating in a copper pipe jacket. The powder is at one and the same time the source material and the water-cooled "container". By the use of stabilisers and controlled cooling, crystal growth occurs from the melt.

PART TWO - APPLIED GEMMOLOGY

Q93. A variety of one particular stone in the orthorhombic system exhibits quite pronounced colour change. What is the name of the stone and the particular variety?

A93. The stone is Chrysoberyl. The variety is Alexandrite.

Q94. Without doing any tests and by observation only, how would you separate a Ruby from an Alexandrite?

A94. Observe both in daylight and then under incandescent light. Alexandrite will appear to be apple green in the daylight but a bright crimson under the incandescent light. The colour change of the Ruby will be barely perceptible.

Q95. Name two common forms in which Garnets will be found.

A95. Garnets will be found as dodecahedrons and as trapezohedrons.

Q96. Which of the following is the best clue to distinguish natural Emerald from Beryl?

- a) Pleochroic effect
 - b) Absorption spectrum
 - c) Optical indicatrix
 - d) Refractive Index.
-

A96. Correct answer is b) Absorption spectrum

Q97. Sinhalite and Peridot can be confused easily. One clue to the identity is the absorption spectrum. In an ideal circumstance, which of the following lines would indicate that the stone under examination was Sinhalite and not Peridot?

- a) 493 nm
 - b) 473 nm
 - c) 463 nm
 - d) 453 nm
-

A97. Peridot has three bands in the blue centred around 497, 474, and 453 nm. Sinhalite has four bands centred around 493, 475, 463, and 453 nm. The answer therefore is c) 463 nm.

PART TWO - APPLIED GEMMOLOGY

Q98. What is Swiss Lapis? How can it be distinguished from Lapis Lazuli?

A98. Swiss Lapis is the common term given to stained Jasper. The SG of Swiss Lapis is around 2.58 compared with 2.7 - 2.9 of Lapis Lazuli. The Swiss Lapis blue is an inferior colour, it has a more vitreous lustre, and it contains small veins and patches of transparent Quartz. Lapis Lazuli has the characteristic flecks of Pyrites.

Q99. What is Malaya or Umbalite Garnet?

A99. Malaya Garnet is one in the pyrope / almandine / spessartite intermediate series.

Q100. In what colours is Topaz found? Name one locality in Australia known to be a source of Topaz.

A100. Topaz occurs as colourless, blue, yellow, brown, grey, red. Oban, Mudgee, and Gulgong, all in NSW, are areas where Topaz is found.

Q101. What is the chemical which gives the green colour to Alexandrite and which also accounts for the colour change to red when examined under incandescent light?

A101. Chrome oxide in small-scale replacement of the alumina.

Q102. What are organ-pipe lines?

A102. Under optimum conditions, these are emission lines sometimes seen at the red end of the absorption spectrum of Spinel (both natural and synthetic). They are a group of about ten lines. Two at 686 nm and 675 nm are strong. There are three weak lines a little towards the red end of the spectrum and a further five a little towards the yellow.

PART TWO - APPLIED GEMMOLOGY

Q103. Describe how Beryl crystallises i.e. what crystal system and what terminations.

A103. Beryl crystallises in the hexagonal system with six-sided prisms. Emerald usually has flat-faced terminations joining the prism faces. Other Beryl varieties generally have small pyramidal faces between the prism faces and the pinacoidal terminations.

Q104. With respect to Diamonds, what is the difference between a trigon and an etch pit?

A104. A trigon is a triangular shaped depression on the face of the crystal, the orientation being at 180 degrees to the octahedral face. An etch pit is a similar marking following the orientation of the crystal face.

Q105. It is a matter of record that Quartz has about 40 known inclusions. Why does Quartz have so many inclusions?

A105. Quartz is one of the last minerals to develop from cooling magma, and thus will include many previously formed solids, liquids and gases.

Q106. How would you describe in simple terms the Quartz variety Chalcedony?

A106. Chalcedony is a microcrystalline Quartz in which fibrous crystals of Quartz are embedded in opal. Agate is a more banded variety of Chalcedony.

Q107. Describe a trapische Emerald.

A107. The trapische Emerald, found in the Chivor and Muzo districts of Colombia, consists of a central, hexagonal, crystal prism emanating from which are six radial prisms, rather like the axle and spokes of a wheel. The space between the spokes is filled with fine-grained, colourless Beryl.

PART TWO - APPLIED GEMMOLOGY

Q108. What is nyf? What are crinkles?

A108. Nyf is the term given to the gum-like skin coating some rounded natural Diamond crystals. Stones which have the appearance of grooves, scales or corrugations as a consequence of stepping of octahedral faces, which in turn causes the Diamond crystal to look rounded, are known as crinkles.

Q109. What is Cornelian (or Carnelian)?

A109. Cornelian is a deep, clear, red-coloured variety of Chalcedony.

Q110. In which crystal system does Chrysoberyl crystallise? How many optic axes does it have? How many RI's does it have?

A110. Orthorhombic is the system in which Chrysoberyl crystallises. As such it is biaxial and so has two optic axes (or two directions of single refraction) and three RI's. These RI's are called alpha, beta and gamma.

Q111. Other than Colombia, name four geographical sources of Emerald.

A111. Emerald is found in Austria (Habachtal Emeralds), the Urals in USSR, Poona Western Australia and Emmaville New South Wales, Transvaal South Africa, Rhodesia, various states of India, near Chitral in West Pakistan, Lake Manyara Tanzania, Eidsvoll Norway, North Carolina USA.

Q112. Hardness in Diamonds is variable. One factor influencing hardness is the geographical location of formation. Which two countries in the world produce the hardest Diamonds?

A112. Australia and Borneo.

Q113. What colours are generally observed when Alexandrite is examined with a dichroscope?

A113. Deep red (alpha ray), orange-yellow (beta ray), green (gamma ray).

PART TWO - APPLIED GEMMOLOGY

Q114. What is a Spinel twin?

A114. Spinel will crystallise in octahedral form. Frequently it will twin on the octahedral face producing flattened triangular forms. As it is a common occurrence in Spinel, this type of twinning is known as Spinel twin. It also occurs in Diamond.

Q115. What is Carbonado? Of what importance is it in gemmology?

A115. Carbonado is a black microcrystalline mass. It has no use in gemmology but because of its considerable hardness as well as toughness it has industrial applications.

Q116. What are knots or naats?

A116. Twinning in Diamonds will produce hard spots. These hard spots are known as knots.

Q117. Generally, what will be observed when yellow and brown Chrysoberyls are subjected to UV radiation, and why?

A117. There will be an absence of luminescence because these stones are rich in iron. The presence of iron in gemstones inhibits luminescence.

Q118. Why is the absorption spectrum of natural blue Spinel different from that of synthetic blue Spinel?

A118. Blue Spinel in the natural state is coloured by ferrous iron and shows lines in the blue region with a strong band centred at 458 nm and a narrow band at 478 nm. Synthetic blue Spinel is coloured by cobalt, not iron, and the spectrum shows three strong bands in the orange and yellow regions.

Q119. How many facets are there on a full, brilliant-cut Diamond?

A119. The crown has 32 facets plus the table. The pavilion has 24, and may or may not have a culet. Modern practice is to have no culet. Thus total facets are either 58, or 57 if no culet is cut.

PART TWO - APPLIED GEMMOLOGY

Q120. Chemically, what are the differences between pure Corundum, Ruby, Blue Sapphire, Yellow Sapphire and Green Sapphire?

A120. Pure Corundum is Al_2O_3 . Ruby is Al_2O_3 with traces of Cr^{2+} . Blue, Yellow and Green Sapphires are also Al_2O_3 , coloured respectively with traces of Ti, Fe^{2+} and Fe^{3+} .

Q121. Name 5 gemstones associated with contact metamorphic rocks.

A121. Some are Axinite, Diopside, Epidote, Fluorite, Garnet (Andradite and Grossular varieties), Iolite, Lapis Lazuli, Peridot, Quartz, Sapphire, Scapolite, Topaz, Tourmaline, Zoisite.

Q122. What is the chemical used to stain Pearls a black colour? How may this be detected?

A122. Silver nitrate. This is best detected using X-rays and photo-sensitive film. The black staining penetrates the Pearl surface fractionally. It is partly opaque to the X-rays and shows clearly on the film as a thin line around the surface of the Pearl and the hole if one is drilled.

Q123. What are the "shape" categories into which Diamonds are initially sorted?

A123. 1. Stone - well-formed crystals.
2. Shape - poorly-formed crystals i.e. those difficult to cut.
3. Macles or flats - twinned crystals.
4. Cleavage - broken crystals.
5. M       - mixed material generally less than one carat.

Q124. What are the 5 characteristics generally recognised as being the most important in assessing the quality of precious Opal?

A124. 1. Colour. The more red, the higher the rating.
2. Brilliance and translucency.
3. Depth of colour e.g. cabochon of solid versus a thin bar.
4. Pattern. A large even pattern is preferred.
5. Darkness of background.

PART TWO - APPLIED GEMMOLOGY

Q125. Kashan synthetic Rubies and natural Rubies are exceedingly difficult to distinguish from each other. Which test is currently (1983) considered to be the most reliable?

A125. The use of a microscope to examine the interior of the stone is the most reliable method. Presence of characteristic Ruby inclusions such as Rutile needles intersecting at 60 degrees in Burmese Rubies, or heavy opaque inclusions surrounded by liquid feathers or tension cracks in Thai Rubies are reliable indicators of natural Rubies. Those which have what appear to be at first sight natural inclusions must be most carefully examined, as the flux-melt method of production of Kashan Rubies produces flux inclusions which can fool the unwary.

Q126. What is meant by the term "putting windows in Diamonds"?

A126. Windows are pairs of facets cut parallel and opposite each other on a rough Diamond for the purpose of allowing inspection into the stone to determine the purity or otherwise.

Q127. Name five gemstones associated with regional metamorphic rocks.

A127. Some are Garnet, Emerald, Spinel, Sapphire, Chrysoberyl, Kyanite, Tourmaline, Jade.

Q128. What is a simple way of distinguishing between a Rock Crystal ball and one made of glass?

A128. Look through the ball at dot on a piece of paper, and rotate the ball in different directions. Because Quartz is doubly refractive (except along the optic axis) the dot will appear doubled. When viewed through a glass ball one only dot will be observed.

Q129. In a full, brilliant-cut diamond, what is the size, expressed in degrees, of the angle between any back facet and the plane of the girdle?

A129. 40 degrees 45 minutes, or approximately 41 degrees.

PART TWO - APPLIED GEMMOLOGY

Q130. What are the colours in which Aquamarine occurs? What is regarded as the most desirable colour?

A130. Aquamarine can be from colourless through just the faintest hint of blue to an intense deep blue. Best Aquamarine is a limpid sea blue. The presence of green detracts from the value of the stone. The colour should be completely even throughout.

Q131. There is often doubt about the use of an ultrasonic device for cleaning gemstones. With the exception of Opal, cemented doublets and stringed Pearls, what is a safe method of cleaning gemstones?

A131. Luke warm water, mild detergent, and a very soft brush is an effective and safe method.

Q132. What are the five observations and/or tests which can be made to identify Turquoise positively?

A132. 1. Characteristic colours and texture of Turquoise.
2. SG between 2.6 and 2.9.
3. RI spot or faint shadow at 1.62.
4. Hardness in the range 5 to 6.
5. Absorption spectrum of strong line at 430 nm and weak line at 460 nm.

Q133. Basically, what is Agate?

A133. Agate is banded Chalcedony, sometimes containing Opal substance. The bands can be similar colours or different colours.

Q134. To which mineral group does Citrine belong?

A134. Citrine is one of the Quartz group.

Q135. What colour is Fluorite?

A135. Fluorite can be colourless, red, orange, yellow, green, blue, violet, and nearly black.

PART TWO - APPLIED GEMMOLOGY

Q136. Which blue stone can have an RI near that of Sapphire, is strongly pleochroic, has a dispersion as great as that of Diamond, and shows a strong blue fluorescence under UV light?

A136. Benitoite.

Q137. In which crystal system does Diopside form?

A137. The monoclinic system.

Q138. What are the colours of Kornerupine? With which stones can it be confused?

A138. Green and green-brown. It can be confused with Enstatite and Tourmaline.

Q139. Where is Alexandrite found in commercial quantities?

A139. Sri Lanka, Rhodesia, Burma, Brazil, Malagasy Republic, USA, Tasmania.

Q140. What is Jasper?

A140. It is generally held that Jasper is Chalcedony containing up to 20% of foreign material. This latter gives it a multicoloured, striped and spotted appearance.

Q141. What is dentine Ivory?

A141. Dentine Ivory is the organic substance of the tusk of elephant, walrus, hippopotamus etc.

Q142. What are the colours of Citrine?

A142. Light yellow to gold-brown.

PART TWO - APPLIED GEMMOLOGY

Q143. Name the major varieties of beryl other than Aquamarine and Emerald. Identify the dominant colour of each. State the geographic occurrence of each.

A143. Golden Beryl is yellow and comes from Sri Lanka and Namibia. Goshenite is colourless and comes from Goshen Mass., USA. Heliodor is lemon yellow to gold and comes from Brazil and the Malagasy Republic. Morganite is pink and comes from Brazil, Malagasy Republic, Mozambique, Rhodesia, Namibia, and California.

Q144. What are the colours of Danburite?

A144. Danburite is colourless, pink, and pale yellow.

Q145. What is Opal?

A145. Opal is hydrated silica.

Q146. What is Malachite? How is it formed?

A146. Malachite is hydrated copper carbonate formed through the dissolving of copper ores and their deposition in the rock cavities and their veins. Essentially it is a natural staining of the rock.

Q147. You are examining a blue stone. You observe that it is strongly trichroic showing a violet-blue, a light-blue and a pale smoky yellow. On the refractometer it shows biaxial readings near to the RI of Quartz. What stone is it most likely to be?

A147. Iolite.

Q148. Where is Boulder Opal found and what is it?

A148. Boulder Opal is found in central Queensland. It is a thin layer of Opal on an ironstone backing. It has been called Nature's doublet.

PART TWO - APPLIED GEMMOLOGY

Q149. What are the colours of Kyanite?

A149. Kyanite is colourless, blue, and blue-green.

Q150. To which mineral group does Agate belong?

A150. To the Quartz group.

Q151. What sort of inclusions can be found in Amber?

A151. Insects, plants, Pyrites, air-bubbles, hair-lines, enclosed liquids.

Q152. Where are commercial deposits of Chrysoberyl mined?

A152. Brazil, Sri Lanka, Burma, Malagasy Republic, Rhodesia, USSR.

Q153. What substances are used to imitate Coral?

A153. Glass, rubber, bone, plastics, horn.

Q154. What are the colours of Diopside?

A154. Light to dark green.

Q155. Where is the largest Precious Opal field in the world?

A155. Coober Pedy, South Australia.

Q156. Does Fluorite fluoresce under UV light?

A156. Yes, usually a strong blue-violet under LW UV.

PART TWO - APPLIED GEMMOLOGY

Q157. Plagioclase forms an isomorphous series from Albite to Anorthite. Within this group there are only two members which are important to gemmologists. Which are these two members?

A157. Oligoclase (Sunstone or Aventurine) and Labradorite.

Q158. What colour is Dumortierite?

A158. Dark blue, violet and red-brown.

Q159. What is Moss Agate?

A159. Moss Agate is a colourless, translucent Chalcedony with moss-like, green hornblende inclusions.

Q160. How can Amber be cleared of some of its inclusions, particularly air bubbles and liquids?

A160. By immersing in heated rape-seed oil.

Q161. What is the reaction of Beryl to UV light?

A161. Including Aquamarine and Emerald, none with the exception of Morganite will fluoresce. Morganite shows a weak violet light.

Q162. What is Dendritic Agate?

A162. Dendritic Agate is a colourless white to grey translucent Chalcedony with tree- or fern-like images called dendrites. These latter are iron or manganese inclusions in black and brown colours.

Q163. How useful is UV light in testing for Aquamarine?

A163. Not at all. Aquamarine does not fluoresce under UV light.

PART TWO - APPLIED GEMMOLOGY

Q164. Name some stones which can be confused with Chrysoberyl.

A164. Andalusite, Brazilianite, Golden Beryl, Hiddenite, Peridot, Sapphire, Scapolite, Sinhalite, natural and synthetic Spinel, Topaz, Tourmaline, Zircon.

Q165. What are the colours of Enstatite?

A165. Brown-green, green, grey, yellowish.

Q166. What is Obsidian? What are the colours in which it is formed?

A166. Obsidian is a volcanic, amorphous, siliceous, glassy rock. It forms in colours of black, grey, brown and green.

Q167. What is "potch"?

A167. Potch is colourless Opal.

Q168. Kyanite is noted for an unusual physical characteristic. What is this?

A168. Hardness of Kyanite will vary between 4 and 7 on the Mohs scale. The vertical axis will be at the lower value, and the hardness across, i.e. the a and b axes, will be higher.

Q169. What is the UV fluorescence and the pleochroism of Kornerupine?

A169. No fluorescence. Strongly pleochroic in green, yellow and brown.

Q170. What is the visual characteristic which is diagnostic of elephant Ivory?

A170. The lines of Retzius or "engine turning" lines.

PART TWO - APPLIED GEMMOLOGY

Q171. What is the effect of subjecting Danburite to UV light?

A171. A sky-blue fluorescence will be observed.

Q172. How is Agate treated to enhance its marketability?

A172. By dyeing in colours of red, yellow, black, brown, green and blue.

Q173. To which crystal system does Aquamarine belong? Does it exhibit pleochroism?

A173. Aquamarine belongs to the trigonal system. Dichroism is definite from colourless to sky-blue.

Q174. In what crystal system does Calcite crystallise?

A174. The Trigonal system.

Q175. What are some commercial geographic occurrences of "Cat's Eye"?

A175. Sri Lanka, Brazil, China.

Q176. What are doublets and triplets of Opal?

A176. A doublet is a slice of light Opal on a patch or other type of material backing. A triplet is a doublet with a clear Quartz (or alternative material) dome cemented on top.

Q177. What is the UV fluorescence and the pleochroism of the blue-green variety of Kyanite?

A177. Fluorescence is strong red. Pleochroism is strong light blue, colourless and dark blue.

PART TWO - APPLIED GEMMOLOGY

Q178. The absorption spectra of Iolite and blue Spinel are similar. Which test would you use to separate them?

A178. Spinel is isotropic and therefore is singly refractive. Iolite is orthorhombic and therefore is biaxially anisotropic. Thus a polariscope or a refractometer will quickly show which is which. Also, it may be possible to tell with the naked eye, because Iolite is strongly trichroic.

Q179. Name three types of Opal formations.

A179. The major formations are Boulder, Matrix, Nobby, Opalised bone, Opalised shell, Opalised wood, Seam and Vertical.

Q180. A variety of Andalusite, known as Chiastolite has an easily recognisable characteristic. What is it?

A180. When viewed down the c axis, a dark cross is seen in cross-section.

Q181. What is a simple test to separate Amber from most imitants?

A181. Put the material to be tested into a strong solution of salt water, (about 10 teaspoons of salt to half a litre of water). Because of its low SG Amber will float whereas all imitants other than Copal Resin will sink.

Q182. Is it possible to get cat's eye Apatite?

A182. Yes. These stones are found in Burma and Brazil.

Q183. Where are the world's largest deposits of Aquamarine?

A183. In Brazil and the Malagasy Republic.

Q184. What colour does Citrine fluoresce?

A184. Citrine does not fluoresce.

PART TWO - APPLIED GEMMOLOGY

Q185. How does Diopside react to UV light?

A185. Diopside fluoresces a strong dark violet.

Q186. What are the best known geographical occurrences of Orthoclase?

A186. Malagasy Republic for the yellow stones. Sri Lanka, Switzerland and Burma for Moonstone.

Q187. What are the colours of Idocrase and the variety called Californite?

A187. Idocrase is olive-green to yellow-brown. The variety Californite is green.

Q188. In which crystal system does Diopside form?

A188. In the trigonal system.

Q189. What is Howlite and what is it used to simulate?

A189. Howlite is a massive ornamental, milk-white and veined with black. It is found in large quantities in California. When stained blue it is used to imitate Turquoise.

Q190. Name three Opal patterns.

A190. The main patterns are Broad Flash, Eye Opal, Harlequin, Liquid Opal, Pinfire, Rolling Flash, and Sun Flash.

Q191. Where is Agate found in large commercial quantities?

A191. In the South American countries of Brazil and Uruguay.

PART TWO - APPLIED GEMMOLOGY

Q192. You are examining a parcel of cut stones, all of which are the same type of gemstone and which are a mixture of colourless, wine yellow, and pink. Your instant diagnosis is that they are Rock Crystal. But then you observe dichroic colours. So you think that they may be Topaz. To check your diagnosis you do a UV test, but lo and behold, no fluorescence. Dismay. What can these stones be?

A192. Phenacite can look like Rock Crystal and like Topaz. Rock Crystal is singly refractive, therefore no dichroism. Topaz will not fluoresce but Phenacite will. An RI test will give further confirmation.

Q193. What is observed when Amber is subjected to UV light?

A193. It will fluoresce a bluish-white to yellow-green.

Q194. Fluorite comes in many colours and will fluoresce a strong blue-violet under LW UV light. It belongs to the isometric system. Is Fluorite pleochroic and why?

A194. No gemstone in the isometric system is pleochroic because all stones in the isometric system are singly refractive.

Q195. What are the dichroic colours of Spinel?

A195. Spinel forms in the isometric system, is therefore singly refractive and hence no dichroic colours.

Q196. What are the two gem varieties of Spodumene?

A196. Hiddenite, and Kunzite.

Q197. What is Indicolite? How may it be distinguished from Blue Sapphire?

A197. Indicolite is Blue Tourmaline. An RI test will show Indicolite at 1.62 to 1.64, and Blue Sapphire at 1.76 to 1.77.

PART TWO - APPLIED GEMMOLOGY

Q198. Would you expect to see dichroism in a well cut Ruby if you looked through the table facet? Why?

A198. No. The best colour in Ruby is seen when it is viewed at right angles to the basal plane, in other words along the c axis. This is the direction of the optic axis which is the direction of single refraction.

Q199. What are the colours of potch or common Opal?

A199. Amber, black, blue, clear, grey, and white.

Q200. With what can Idocrase be confused?

A200. Demantoid, Epidote, Peridot, Smoky Quartz, Tourmaline, and Zircon.

Q201. To which crystal system does Amber belong?

A201. None. Amber is amorphous.

Q202. What stones can be confused with Aquamarine?

A202. The most likely ones are Euclase, glass, Kyanite, Synthetic Spinel, Tourmaline, Zircon.

Q203. Which gemstone can look very much like Smoky Quartz? What tests will distinguish between the two stones?

A203. Axinite. RI and SG are quite different. Also, Axinite has definite absorption lines at 512, 492, 466 and 415 nanometres. Smoky Quartz on the other hand exhibits no absorption spectrum.

PART TWO - APPLIED GEMMOLOGY

Q204. The mineral Cassiterite will occasionally crystallise. When it does:

- a) what is the crystal system?
 - b) What are the colours?
 - c) What is one fairly conclusive test?
-

A204. a) Tetragonal.
b) Reddish-brown.
c) Its SG at 6.8 to 7.0 is higher than that of most other gem material.

Q205. What is Chalcedony?

A205. The word Chalcedony is used in two contexts. Firstly it is used as a generic term to categorise a group of microcrystalline Quartz stones, e.g. Agate, Chrysoprase, Cornelian, Fossilised Wood, Heliotrope, Jasper, Onyx to name some. Secondly it is used to identify the blue/white/grey variety of Chalcedony. Chalcedony is a microcrystalline or cryptocrystalline Quartz in which fibrous crystals of Quartz are embedded in an amorphous Opal (hydrated silica).

Q206. What are the factors which cause the colour change in Alexandrite?

A206. 1. The transmission characteristics of the red part and of the green-blue part of the absorption spectrum are quite similar. Thus in daylight which is rich in blue, the stone appears green. In red-rich incandescent light the stone appears red.
2. Alexandrite has strong pleochroism. In natural light it shows Emerald green, yellowish, columbine red. Under incandescent light it shows Emerald green, reddish yellow, and red.

Q207. What is Eilat stone?

A207. Eilat stone is Chrysocolla intergrown with Turquoise and Malachite.

Q208. Which of the many Chalcedony varieties is considered to be the most prized?

A208. Chrysoprase.

PART TWO - APPLIED GEMMOLOGY

Q209. How common is Citrine? Is it artificially produced?

A209. Natural Citrine is now rare. Much Citrine on the market is heat-treated Amethyst or Smoky Quartz.

Q210. What are the preferred colours of Coral?

A210. Red, pink, gold, white, black.

Q211. What is the colour of Dioptase?

A211. Emerald green.

Q212. To which crystal system does Dumortierite belong? What would you expect to see when it is viewed with a dichroscope?

A212. Orthorhombic. Strong pleochroic colours of red, a range of browns and sometimes almost black.

Q213. Is Enstatite pleochroic?

A213. Yes. The definite colours of green and yellow-green may be seen.

Q214. What are the colours of Epidote?

A214. Green, dark brown, yellow, red.

Q215. What are the colours of Euclase?

A215. Colourless, light blue, sea-green.

PART TWO - APPLIED GEMMOLOGY

Q216. Oligoclase is frequently colloquially called what? What minerals give Oligoclase its unique appearance?

A216. Sunstone or Aventurine. The spangled effect is caused by the presence of flakes of Haematite or Goethite.

Q217. a) What is the colour of a Haematite polished stone?
b) What is its diaphaneity?
c) What is the colour of a thinly cut section of Haematite?
d) What is its diaphaneity?

A217. a) black, black-grey, brown-red.
b) Opaque
c) Red.
d) Transparent to translucent.

Q218. The Moss Agate and Dendritic Agate have particular inclusions. What are the chemicals which cause these?

A218. Black coloured - manganese oxide. Green coloured - chlorite. Red coloured - iron.

Q219. The inclusion shaped like a centipede is characteristic of which stone?

A219. Moonstone, the Orthoclase Feldspar.

Q220. What is Prase?

A220. Prase is a compact Quartz aggregate, generally leek-green in colour, and with Actinolite inclusions.

Q221. What are two simple tests which collectively would strongly suggest that a red stone is Ruby?

A221. When viewed through a Chelsea filter a Ruby shows a vivid, almost fluorescent red. When viewed through a dichroscope the twin colours of Ruby will be a deep carmine and pale yellowish red. If a spectroscope is used the distinctive absorption spectrum of chromium will be seen. This latter is characterised by a fluorescent doublet in the red.

PART TWO - APPLIED GEMMOLOGY

Q222. What are the colours of Spodumene?

A222. Hiddenite is yellow, yellowish-green, ice-green, and grass-green. Kunzite is lilac-pink.

Q223. Zoisite can look remarkably like blue Sapphire. What simple instrument test will conclusively separate Zoisite from blue Sapphire?

A223. Using a refractometer, the RI of Sapphire will be 1.76 to 1.77, whereas for Zoisite it will be 1.69 to 1.70. Perhaps a quicker but not necessarily so conclusive test is to use a dichroscope. Sapphire is dichroic whereas blue Zoisite is trichroic

Q224. Would you say that Cassiterite has a high or low dispersion?

A224. At 0.071 it is high. Diamond is 0.044; Zircon is 0.039.

Q225. How would you describe the appearance of Chrysocolla?

A225. Chrysocolla is a cryptocrystalline mineral of greasy to vitreous lustre. The colours are a predominant sky-blue to turquoise blue with patches and spots of blue-green to dark green.

Q226. What is the usual colour of Chrysoprase?

A226. Pale green and apple-green.

Q227. Can natural Citrine be distinguished from heat treated Quartz?

A227. Sometimes. Natural Citrine has a weak yellow and light yellow dichroic effect. Heat treated Quartz stones show no dichroic effect. Sometimes the banded effect present in the untreated stone will remain in the treated stone.

PART TWO - APPLIED GEMMOLOGY

Q228. What is the colour of Cornelian? What is the mineral which causes this colour?

A228. Flesh-red to deep red. Caused by the presence of iron.

Q229. Diopside fluoresces strongly under UV. Does Dioptase react similarly?

A229. No. Dioptase is inert.

Q230. What is the gold-coloured, speckly inclusion in Lapis Lazuli?

A230. Pyrites.

Q231. Name some inclusions common to Burma Rubies.

A231. Short rutile needles intersecting at 60 and 120 degrees, and vertical to the C axis. Well-formed octahedral Spinel, Zircon, Calcite, mica. Note that colour swirls and liquid feathers are rarely found.

Q232. Name some inclusions common to Ceylon Rubies.

A232. Rutile needles of very fine silk, liquid feathers, solid crystals of Mica, Corundum, Haematite, Garnet, and thin slabs of Calcite.

Q233. Name some inclusions common to Thai/Siamese Rubies.

A233. Heavy opaque inclusions surrounded by liquid feathers or tension cracks. These latter are typical of Thai Ruby. Multiple twinning, Garnets. Rarely does Thai Ruby have Rutile included.

Q234. Name some inclusions common to Tanzanian Rubies.

A234. Multiple twinning with cracks. Umba Valley have Apatite and Graphite. Longido have Spinel and Zoisite.

PART TWO - APPLIED GEMMOLOGY

Q235. Lithium Niobate, GGG, and Strontium Titanate all have a dispersion greater than that of Diamond. Why then are these materials regarded as poor simulants of Diamond?

A235. All have a hardness of 6 or less on the Mohs scale, and are thus subject to easy wear.

Q236. What are the geological occurrences of Topaz?

A236. In granite rocks, pegmatites and gem gravels.

Q237. What are the five recognised commercial types of precious Opal?

A237. a) Solid.
b) Natural composite, e.g. matrix, boulder, painted ladies and natural doublets.
c) Imitation, e.g. plastic.
d) Synthetic, e.g. Gilson and Kyoto ceramics.
e) Laminates, e.g. doublets and triplets.

Q238. Name three dopants used to colour Cubic Zirconia, and the colours they produce.

A238. Some are: Chromium - olive. Cobalt - lilac. Copper - yellow. Iron - yellow. Manganese - brown/violet. Nickel - yellow/brown. Titanium - yellow/brown. Vanadium - green.

Q239. If when examining a blue stone with a dichroscope you observed definite trichroic colours of red-violet, deep blue and yellow-green, what stone is it likely to be?

A239. Zoisite.

Q240. Name four gemstones commonly found in Sri Lanka.

A240. Apatite, Axinite, Beryl (no Emerald), Chrysoberyl, Corundum, Crystalline Quartz, Danburite, Diopside, Enstatite, Garnet, Iolite, Kornerupine, Orthoclase Feldspar, Sinhalite, Sphene, Spinel, Topaz, Tourmaline, Zircon.

PART TWO - APPLIED GEMMOLOGY

Q241. What would you expect to see if you examined a Garnet-topped doublet in water and with a loupe out of water?

A241. Genuine inclusions in the Garnet. Bubbles where the glass adheres to the Garnet. Difference in lustre and transparency of the two materials. A red flash as the stone is turned in the water.

Q242. What are the main geographical occurrences of Chrysocolla?

A242. Western states of the USA, the Congo, USSR, Chile.

Q243. What stones can be confused with Citrine?

A243. Yellow Beryl, Orthoclase, yellow Topaz, yellow Tourmaline.

Q244. Name some commercially viable geographic occurrences of Cornelian.

A244. Cornelian can be found-world wide. Most important deposits are in Brazil, Indo-China, western USA, Uruguay.

Q245. To which crystal system does Epidote belong? Is Epidote pleochroic?

A245. Epidote belongs to the monoclinic system. It possesses strong trichroism of green, brown, and yellow.

Q246. Euclase can be an attractive stone and has a hardness of 7.5, yet it is not a popular gemstone. Why?

A246. Euclase has easy and perfect cleavage, and is difficult to cut without the stone cleaving when it is not intended to do so.

Q247. Name one country where Oligoclase is mined in quantity.

A247. Oligoclase is mined in commercial quantities in Canada, India, Norway, USA and USSR.

PART TWO - APPLIED GEMMOLOGY

Q248. What is Hambergite? Why is it not popular as a gemstone?

A248. Hambergite is a colourless to white very rare gemstone from Kashmir, Malagasy Republic and Norway. It is a brittle stone with easy and perfect cleavage. As such it is unsuitable generally for use as a set gemstone.

Q249. What is Heliotrope? What causes the coloured spots?

A249. Heliotrope is a dark green Chalcedony. The red spots are Jasper.

Q250. With what can Idocrase be confused?

A250. Demantoid, Epidote, Peridot, Smoky Quartz, Tourmaline, Zircon.

Q251. What are common inclusions found in Diamonds from Brazil, India, South Africa and the USSR?

A251. Brazilian Diamonds have Quartz. Indian Diamonds show a Maltese cross as a structural defect. South African Diamonds have Chrome Diopside, Chrome Enstatite and Garnets. Russian Diamonds have Chrome Spinel.

Q252. Name some inclusions common to Corundum.

A252. Rutile needles. "Silk" at 120 degrees. Liquid in cavities. Two and three phase. Fingerprints. Negative crystals. Colour zoning. Twinning. Colour swirls.

Q253. Name some natural and some synthetic material which can be confused with natural Ruby.

A253. Synthetic Ruby. Natural and synthetic Spinel. Tourmaline. Garnet. Paste. Doublet.

PART TWO - APPLIED GEMMOLOGY

Q254. How different are the constants of RI and SG and the birefringence between natural and Kashan Ruby?

A254. These constants are practically identical and are of little use in distinguishing between natural and synthetic Kashan Rubies.

Q255. What is regarded as the most important impurity-type defect in a Diamond? Why?

A255. The presence of nitrogen. Its presence causes Diamond to possess a number of physical characteristics, the most significant being colour change.

Q256. What are some geographical occurrences of Spodumene?

A256. Brazil, Malagasy Republic, USA.

Q257. In which system does Zoisite crystallise? Is it pleochroic?

A257. Zoisite crystallises in the Orthorhombic system; therefore it will be trichroic. The colours are strong. They are red-violet, deep blue and yellow-green in an untreated stone. After heat treatment the colours are violet-red and two occurrences of deep blue. In its natural state the trichroic colours are strong enough to be seen with the naked eye.

Q258. Write some words to explain strontium titanate to an imaginary student.

A258. Strontium titanate is a synthetically produced gemstone. It has no counterpart in the world of natural stones. It is manufactured using titanium and oxygen as the major ingredients in the Vernueil (flame fusion) process. Its main application is as a Diamond simulant as it can be made colourless and it has a high dispersion.

Q259. What is Tiger's Eye?

A259. Tiger's Eye is a yellow, chatoyant, silica pseudomorph in the Quartz group.

PART TWO - APPLIED GEMMOLOGY

Q260. Pure Turquoise in the natural state is rare. Mostly it is found containing matrix. What are these matrices and how can they be identified by colour?

A260. Veins of matrix are usually in one of three colours in a specimen of Turquoise. Brown is caused by Limonite. Dark grey is caused by sandstone. Black is caused by Jasper.

Q261. What are the colours of Variscite?

A261. Apple-green and blue-green.

Q262. How is Chrysoprase imitated? How can it be detected?

A262. It is imitated by staining Agate green by the precipitation of nickel or chromium salts. When viewed through the Chelsea filter, Chrysoprase is green. Stained Agate on the other hand is a brownish-red colour. Chromium staining can sometimes be detected by the presence of chromium absorption lines in the red part of the spectrum. Another clue is the mosaic markings caused by dye concentration seen with x40 magnification.

Q263. What are the geographic occurrences of natural Citrine?

A263. Brazil, Malagasy Republic, USA, Spain, USSR, France, Scotland.

Q264. How does Spodumene crystallise?

A264. In the monoclinic system, with vertically striated, flattened prisms.

Q265. Briefly and simply explain the Czochralski or "pulled" method of growing synthetic gemstone materials.

A265. A seed crystal is dipped into molten source material then slowly pulled out. During this process the seed grows.

PART TWO - APPLIED GEMMOLOGY

Q266. Do any of the Feldspars fluoresce? Are any pleochroic?

A266. All Feldspars have a weak fluorescence, the colour of fluorescence depending upon the variety under test. Pleochroism is not seen in any variety except Aventurine where it is quite weak.

Q267. Name some inclusions common to Burmese Rubies.

A267. Short Rutile needles at 60 and 120 degrees perpendicular to the C axis; well formed octahedral Spinel, Zircon, Calcite, Mica.

Q268. Name some inclusions common to Australian Sapphire.

A268. Colourless Zircon often with symmetrical prism faces. The bigger of these have haloes. Silk with iron staining, liquid feathers. Typical is the "butterfly" inclusion. Others are Spinel in irregular grains, Feldspar crystals, Ilmenite and Magnetite.

Q269. You have three Rubies. One is a fine rich red colour, the second is a dark red and the third is more pink than red. What is a likely geographic location where each of these Rubies was formed?

A269. The first could be from Burma, the second from Siam and the third from Ceylon.

Q270. You are observing a red stone with a spectroscope and you detect some "lines in the red". Which of the following could this stone be? Ruby, Spinel, Garnet, Zircon, Paste, Doublet, Tourmaline?

A270. Ruby, Spinel or red Zircon. Ruby shows a strong doublet at 694 nm and 693 nm. Spinel has lines at 686, 675, and 665 nm. Red Zircon has lines around 654 nm.

Q271. Name two natural crystals which have vertical striations (parallel to the C axis) on the crystal faces, and two which have horizontal striations (perpendicular to the C axis).

A271. Peridot, Aquamarine, Spodumene, Topaz, Tourmaline all show vertical striations. Corundum and Quartz all show horizontal striations.

PART TWO - APPLIED GEMMOLOGY

Q272. How can Lechleitner Emeralds be readily detected?

A272. They have a network of fine cracks on the surface. Also parts of the pavilion may be unpolished to retain colour.

Q273. Which synthetics are produced by the Czochralski or "pulled" method?

A273. Ruby, Alexandrite (Chrysoberyl), YAG, Scheelite, Lithium Niobate.

Q274. Name two Diamond simulants and identify how each reacts to UV light.

A274. Synthetic Corundum - light green under LW. Synthetic Spinel - bright pale blue under SW. Zircon - mustard under LW. CZ - has a variable reaction to UV.

Q275. Briefly and simply explain the flux melt or super-saturated method of growing synthetic gemstone material.

A275. Gem material is dissolved in lithium molybdate and heated in a platinum crucible. Seeds are lowered into the mix. As the temperature is slowly reduced, the seed crystal grows.

Q276. Name some inclusions typically occurring in Colombian Emeralds.

A276. Common to most Colombian Emeralds are three-phase inclusions with saw-tooth-like edges. The Chivor Emeralds have well developed Pyrite crystals. Muzo Emeralds have well shaped rhombohedral Calcite crystals. Diagnostic of Muzo Emeralds are Parisite crystals, dark brown to red-brown to yellow in colour.

Q277. What is the occurrence of Kashan Rubies? In what colours do they appear?

A277. Kashans are synthetics. They can be produced in almost any variation of red, from pink through brown and orange, bright to dark red, and with shades of violet to an almost black appearance.

PART TWO - APPLIED GEMMOLOGY

Q278. To which crystal system does Sphene belong? Is it pleochroic? Does it have high or low dispersion?

A278. Sphene belongs to the monoclinic system and is therefore biaxial. It is strongly pleochroic. The yellow variety is trichroic showing colourless, yellow and reddish. Dispersion at 0.051 is high.

Q279. How does Spodumene react to UV light?

A279. Hiddenite shows a very weak red-yellow. Kunzite shows a strong orange to red-yellow.

Q280. Name at least three gem materials synthesised by the Verneuil or flame fusion process.

A280. Ruby, Sapphire, Spinel, Synthetic Rutile, Strontium Titanate.

Q281. What synthetics are produced by the Hydrothermal or aqueous solution method?

A281. Lechleitner Emerald, Linde Emerald, Quartz, Ruby.

Q282. Name some inclusions occurring in at least four of the Garnet varieties.

A282. Almandine - Rutile needles intersecting at 110 degrees, Mica flakes, colour banding, Apatite crystals, liquid inclusions and Zircon haloes.
Demantoid - Byssolite horse-tails, golden against green.
Grossular - Actinolite and Apatite crystals.
Hessonite - Rounded Zircon crystals in great numbers, colour swirls.
Spessartite - Healed fractures like Spanish mantilla.

Q283. With reference to question 198, if the crystal of the Ruby had been synthetically produced, what would you be most likely to see with the dichroscope? Why?

A283. Because the synthetically produced boule is split longitudinally, the gemstones are not usually cut with the table facet perpendicular to the C axis. Dichroism can therefore be apparent when viewed through the table.

PART TWO - APPLIED GEMMOLOGY

Q284. In what colours does Sphene occur? What are the major geographical occurrences? Can it be confused with other stones?

A284. Sphene occurs in yellow, green, brown and grey. It is found in Switzerland, Mexico and Burma. It can be confused with Amblygonite, Apatite, Brazilianite, Enstatite, some Garnets, Sphalerite and some Tourmaline.

Q285. What are the pleochroic colours of Spodumene?

A285. Hiddenite shows blue-green, yellow-green and Emerald-green. Kunzite shows an Amethyst colour, pale red and colourless.

Q286. What synthetics are produced by the flux melt or supersaturated method?

A286. Chatham Gilson and Zerfass Emeralds, Kashan Ruby, Spinel, Quartz, GGG, Alexandrite.

Q287. How may Linde Emeralds be readily detected?

A287. There will be evidence of the seed crystal inside when inspected with a microscope. Also, it may have feather- and/or nail-like inclusions.

Q288. What is the geological occurrence of Topaz?

A288. Topaz occurs in highly acid igneous rocks, in pegmatite dykes, and in contact metamorphic rocks.

Q289. How should a Kyanite crystal be cut to obtain the best colour?

A289. It should be oriented and cut with the table facet perpendicular to the C axis.

PART TWO - APPLIED GEMMOLOGY

Q290. How may natural and synthetic Spinel be readily separated? Why?

A290. By SG and RI tests. Natural Spinel has aluminium and magnesium in the ratio 1:1 whereas in synthetic Spinel there are three parts of aluminium to one part of magnesium. This causes the differences in the SG and RI readings. Also, it causes a strain in the crystal lattice structure of the synthetic Spinel. This is evident by anomalous double refraction when the stone is examined with a polariscope.

Q291. Name and briefly describe two simple tests which will aid in separating natural and cultured Pearls.

A291. SG Test. - A high proportion of salt water pearls have an SG of less than 2.71 and a high proportion of cultured Pearls have an SG of greater than 2.71.
Candling. - A strong, point-source light behind the Pearl in a darkened room will generally show stripes in the cultured Pearl, and an absence of these in a natural Pearl.
Magnification. - If the Pearl has a drilled hole, a brown, conchiolin separation layer is generally visible between the core and outer nacre layers in the cultured Pearl.

Q292. In what colours does Prehnite occur? With what stones can Prehnite be confused?

A292. Prehnite comes in pale green, yellowish green and occasionally colourless. It can be confused with Chrysoprase, Serpentine, Idocrase and Nephrite.

Q293. What are the colours of Rhodochrosite? Does it have black inclusions?

A293. Shades of pink to brownish with white lacy bands are the usual colours. It has an agate-like structure. Black coloured inclusions are very rare.

Q294. What colour is Rutile? What is the lustre of polished Rutile?

A294. Rutile is a transparent, red-brown colour. The lustre is strong and almost metallic.

PART TWO - APPLIED GEMMOLOGY

Q295. What is the colour of Scheelite? What colours does it fluoresce?

A295. Scheelite is coloured brown, orange, red, yellow and colourless. It fluoresces blue, whitish or yellow.

Q296. What type of cleavage, if any, does Topaz exhibit?

A296. Topaz has easy basal cleavage.

Q297. What are the common simulants for Kunzite? How may they be detected?

A297. Glass, pink Topaz, synthetic Spinel, and natural bluish-pink Amethyst. In the case of glass and synthetic Spinel, these are singly refractive. The R.I. of each of Topaz, Amethyst and Kunzite are all different, and the birefringence of Kunzite is twice that of the other two stones.

Q298. Briefly and simply, explain the Verneuil or flame fusion method of growing synthetic gem material.

A298. Powdered source material is dropped through a flame at 2200 degrees Celsius. The material melts and falls to the bottom of the furnace where it solidifies. As this process continues a boule starts to grow from the bottom upwards. The base is gradually lowered as the boule grows until it reaches a length suitable for cutting.

Q299. What type of inclusions are to be found in flame fusion synthetics?

A299. Round elliptical and flask-shaped bubbles, undissolved powder, growth lines, curved colour zoning. Colour zoning can sometimes be better seen with the stone immersed in water.

Q300. In which crystal system does Topaz crystallise? What pleochroic effects does it exhibit?

A300. Topaz crystallises in the Orthorhombic system. Generally the pleochroic effects are distinct but not strong. The colours are trichroic and depend upon the predominant colour in the stone.

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